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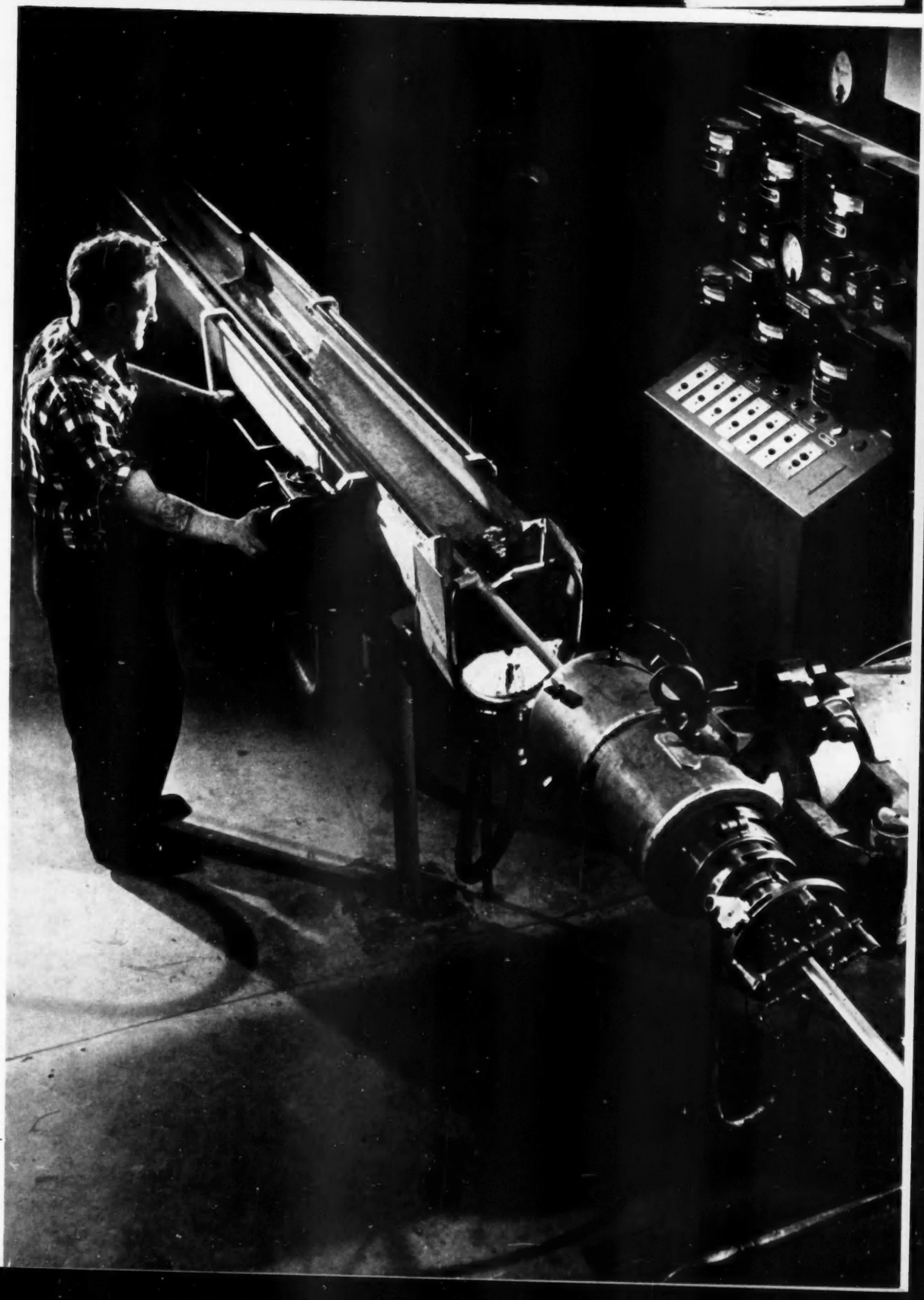

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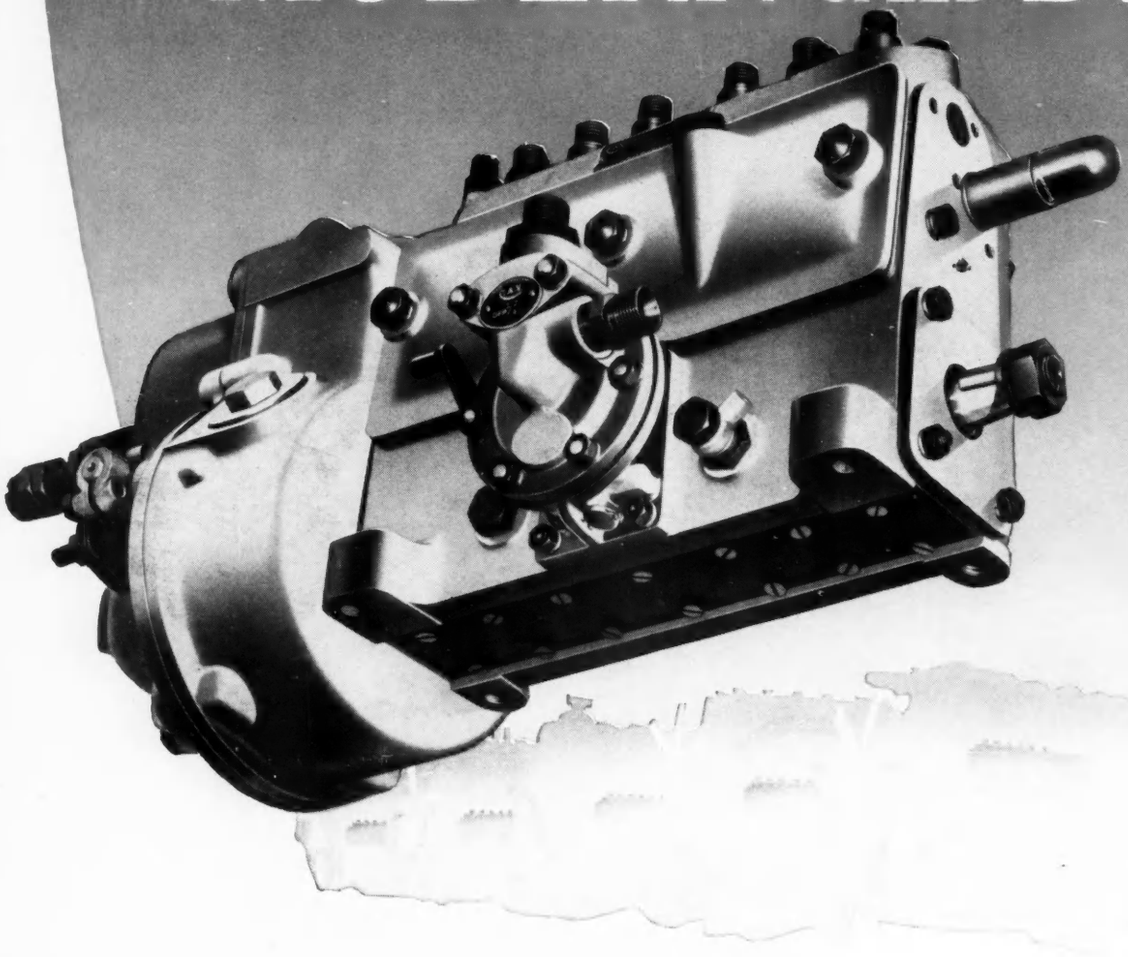

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ENGINEERING

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Contents

589 **Leading Article**
Poll of the Profession

590 **Plain Words**

591 **Letters to the Editor**
Shaw's Alphabet
Industrial Pneumatics

592 **Obituary**
Sir William Halcrow
Dr. S. Livingston Smith, C.B.E.

598 **Companies in the News**

600 **Special Article**
Geneva Distillate: 3—Propulsion

603 **Atomic Review**
Under Cover

612 **Book Reviews**
Linear Programming and Economic Analysis
Dynamic Programming
Kinematisch-getriebeanalytisches Praktikum
Uranium and Thorium
The Effects of Radiation on Materials
Zone Melting
The Effects of Furnace Atmospheres on the Sintering Behaviour of Uranium Dioxide

613 **On the Shelf**

617 **Notices of Meetings**

620 **Engineering at Home**
In Time with Crystals
Wooden Posts Stronger
Tailoring Radio to Ear and Brain

. . . . . .

590 **Management**
Weekly Survey

593 **Plant and Equipment**
Dust Free Assembly
Air Transport Containers
Replacing Sunshine
Ball Bearing History
Vehicle Gas Turbine
Industrial Sander
Flash Clipping Press
Antarctic Compressor
Haulage Winch

Plant for the Contractor: Preview of the Public Works Exhibition

599 **The Human Element**

605 **Construction**
Wedge Anchor for Prestressing System
Heating and Ventilating Deep Underground Spaces
New Lines in Space Heating

606 **Design**
How to Cross an Unsafe Bridge: A Diversion in Dynamic Plasticity
Noise: Symposium held at the I.Mech.E.
Progress of 50-Cycle Traction Technique in the Congo
Waste Heat Recovery from Diesel Engines

611 **Marketing**

614 **Production**
International Production Engineering Research
Swiss Engineering Anniversary

616 **Metals and Materials**
Colour and Texture for Aluminium Exteriors
Thermal Conductivity of Vermiculite
Stainless Steel Contains Beryllium
Postgraduate Education in Aircraft Materials

618 **Research and Development**
Fatigue Strength of an Embedded Point Carrying a Shear Load
Non-Competitors Pool their Research
Measuring Humidity

Poll of the Profession

A YOUNG Canadian sociologist, Mr. Bruce McFarlane, is conducting a survey of chartered engineers in the United Kingdom. He has sent questionnaires to several hundred engineers, who have responded well. The information he is thus obtaining will, of course, be used anonymously, but it should reveal more about the motives, the paths to success, the attitudes to work and many other fascinating aspects of the profession than anything done previously.

The Engineers Guild has already sent out questionnaires for its own current survey to a larger sample—9,900—and according to their latest statement about 65 per cent have been completed and returned. The final return is expected to be higher. Mr. McFarlane's purpose, however, differs from that of the Guild. His questions are designed "to cast light on some of the factors involved in the choice of engineering as a career, recruitment to the profession, the engineer's educational background, his training and subsequent career." Having conducted a similar survey in Canada, he is well equipped to study the situation in this country. He says that the response to his questionnaires has been good. This satisfactory result is doubtless due in part to the very complete and thorough nature of the questionnaire. He has not just asked a few simple questions but has dug right down to the basic factors. Anyone who has been fortunate enough to receive one of the forms will have enjoyed replying to a man who so clearly understands the finer points of the profession.

We do not hear quite so much as we used to about the shortage of engineers. Perhaps it is not as serious as it was, though in Western Europe generally it is evidently still a problem for governments. The Council of the Organisation for European Economic Co-operation (OEEC) at a recent meeting reviewed the position so far as Western Europe is concerned. The Council's plans for the immediate future include steps to improve the teaching of science and mathematics at secondary school level, a programme for the international exchange of senior scientists, and the support of training institutions in highly specialised scientific fields. When next year's plans come up for discussion in December the Council will have the encouragement of an offer from the United States Government to increase its contribution from $500,000 to $750,000, to be matched by an equal contribution from OEEC countries. In the next year the programme of OEEC includes measures to improve the data on the demand and supply of scientists and engineers, and specific proposals for improving forecasting techniques.

The reason that OEEC are involved in these matters is, according to the secretary-general, because they are convinced that "the economic growth of Western Europe depends in substantial measure on the underlying strength of its science-based industries. This industrial strength is possible only if the countries of Western Europe make full use of the rich potential of their human resources." The Organisation has already sponsored two international demonstration courses for secondary school teachers, and they are starting a programme of senior visiting fellowships to increase the flow of men between training or research institutions in member countries. They are also studying different national methods of providing additional training and education to those already serving in industry.

Meanwhile an appraisal of Britain's own needs has been made by Mr. A. A. Part, head of the further education branch of the Ministry of Education, in a recent talk at the Administrative Staff College at Henley. The extra 10,000 scientists and technologists a year estimated to be needed by 1970, he states, can be supplied if the technical colleges continue to expand at the present rate. This is good news. But the question of differing standards must not be overlooked. Do we mean the same thing as the Germans or French when we talk about an engineer? Here some of the measures in the OEEC programme are important. These are the proposals for establishing "international comparability of definition and equivalence of professional titles." In other words, make sure that like is being compared with like. Perhaps the OEEC's first annual review of methods of training personnel, in which Britain is taking part this month, will be one step in this direction. But it is a forlorn hope to expect that strict comparability will ever be achieved. In Britain alone there are many different views on the definition of a professional engineer.

As an indirect method of helping to unite Western Europe, these activities of OEEC are helpful. But there tends to be too much discussion without adequate data—not only in the Organisation but throughout the engineering profession and industries. That is why Mr. McFarlane's study is so important. It will give some facts and statistical evidence where before we have been fed on a diet of generalisations garnished with a few not very vital statistics.

Cover Picture.—*Applying a pvc cover over an aluminium-sheathed cable to provide protection against corrosion. Eliminating lead from the sheathings makes for a lightweight cable so that about 2 miles of 11·5 kVA underwater cable can be wound on a drum and weigh no more than 20 tons.* (*Nurnberg photograph for* ENGINEERING)

* * *

Plain Words

A few days ago I happened to be talking to a young man in the second year of his graduate apprenticeship with an engineering firm. He was complaining bitterly that it was all a waste of time. "Bored," he said, "I'm thoroughly browned off. Do you know, when I was in the welding shop, I had nothing to do but stand around all day with my eyes shut—or very nearly." I asked him how that was. "Well," he said, "the union won't let me use a welding tool and the foreman hasn't any eye shields to spare. So I couldn't weld and I couldn't watch."

I didn't question his lack of enterprise in failing to find some way in which to occupy himself, for I remember feeling much the same myself. But now I know better. Looking back, I can think of a thousand little things I learnt that at the time meant practically nothing. It wasn't only the technical stuff; I also came to know a great many people I might not otherwise have met. There was the moulder who had a minor reputation in the archaeological world and the tool maker whose paintings were reviewed in the national Press.

And there was Ted. He taught me all I know about fixing things—one way or another. He was the service man and we spent two glorious weeks travelling about the West Country in the service van, checking up on pumping plant. He also made me careful when using hotel bathrooms.

We had had a hard day and decided to do ourselves proud in a good hotel. There was only a double room left on the top floor of the County, but we took it. After dinner I stayed in the lounge to read, while Ted went to have a bath. When I came up, there was pandemonium: I could hear water splashing down from a great height into the courtyard and an angry voice was calling up from where it landed. And there was Ted in the corridor wearing nothing but a towel and surrounded by chambermaids and porters. Apparently he had decided to get undressed in the bedroom and dash into the adjacent bathroom in a towel. He had switched on the taps and then found he had forgotten the soap. Unfortunately the bathroom had only recently been converted and the door had a yale lock, the catch of which Ted had inadvertently released. The bedroom doors were also self-locking. So there he was, with water overflowing from the bath and no place to hide.

I don't know what it taught me but its a lesson I shall never forget. There's no better way of finding what the world is all about than living in it.

CAPRICORN

Weekly Survey

No Formula for People

In March, 1953, the Department of Scientific and Industrial Research and the Medical Research Council set up a committee to study human relations in industry—to examine current activities and call attention to problems on which research might be undertaken by DSIR and other bodies. The report which this committee has just issued (*Final Report of the Joint Committee on Human Relations in Industry*, 1954-57) states that the main obstacle to the growth of social research in industry is the shortage of trained people. This in turn is due to the lack of reasonable career prospects in this field. There is no easy way of gearing research to industrial needs.

The problem of how to work out a balanced research programme is made almost impossible of solution because there is no point in time at which both the funds available and the whole range of research projects are known. The committee found that the value of social research was not widely appreciated in industry. One explanation put forward for this is "the false expectation that general academic reports can produce cut-and-dried answers to problems as they arise on the shop floor." The report goes on to say "it seems to us wrong to encourage the belief that managements will be able, even in the long run, to apply the results of human relations research in the way that they can use a chemical formula to produce a new product."

The same volume (HMSO, price 3*s*) contains the *Report of the Joint Committee on Individual Efficiency in Industry, 1953-57*. This includes summaries of various research projects sponsored by the committee. One group of these dealt with industrial engineering techniques, another with factors affecting equipment design and working conditions, and a third with problems of training. The summaries of the work done under these headings provide the most interesting part of the report.

Firestreak's Function

"Anything Sidewinder can do, Firestreak can do better," though at greater cost. And if an enemy chose to launch a low-level bomber attack in the sort of weather conditions that prevailed over the United Kingdom during most of this summer, neither the American Sidewinder nor the British Firestreak air-to-air guided missile would be likely to provide us with much protection. These are the main impressions of de Havilland Propellers' progress report on Firestreak.

The weapon is now in production for, and under evaluation by, the Royal Navy and the Royal Air Force, and is destined for the Sea Vixen, the Javelin, and the Lightning interceptors. The comparison with Sidewinder arises out of speculation on the possibility of Sidewinder being ordered for the RAF, on account of its cheapness, simplicity and effectiveness. Both Firestreak and Sidewinder have infra-red homing systems, which cannot function in heavy rain or thick cloud. Infra-red homing is, however, claimed to have advantages over radar in that it is immune from counter measures, is more accurate, and requires no radar illumination of the target either from the launching fighter or the ground. The contention is that fighter versus jet bomber actions are most likely to take place at high altitude, above the weather, and that therefore the infra-red system provides the best solution. But if an enemy decided to sacrifice some performance and come in at low altitude under cloud cover, fighter defence would then, presumably, have to depend on non-guided missiles, since no alternative air-to-air guided weapon has been ordered for the British services.

Meanwhile, Firestreak trials approach the final stages. In firings at Woomera, the percentage of successes achieved amounts to 80 per cent. The weapon is not affected by extraneous heat radiation, from the sun, for example; it is very manoeuvrable, and is provided with both contact and proximity fuses to ensure a kill. The maximum range is between one and four miles, depending on the closing speed of the fighter aircraft and target, the altitude, and the type of target. Firestreak is designed as a pursuit course missile; it can be launched from a position varying from dead astern to well out on the beam. It can also be effectively fired from as much as 10,000 ft below the target. Although highly supersonic, it is designed to deal with bombers in the high-subsonic class. More advanced versions are now under development to deal with the future Mach 2 bomber.

Fossil or Fissile

The fact that Western Europe has to import a growing porportion of its energy requirements in the form of crude oil poses many problems for the future. These were examined by Mr. J. H. Loudon, the managing director of Royal Dutch Shell in a speech to the Netherlands Employers Federation recently. The OEEC Energy Commission's Report in 1956 forecast an increase of 2½ per cent a year in the demand for energy over the next 15 to 20 years. Mr Loudon believes that this may be an underestimate. At present coal supplies over two-thirds of Western Europe's total energy needs, oil and natural gas one-fifth and hydro-electricity the rest. By 1975 total energy demand will have increased by half, but the contribution of coal will have fallen by from 50-70 per cent. Hydro-electricity output will have remained steady and nuclear energy will have come in with a share of around 7 per cent. It follows, says Mr. Loudon, that the major part of the increase in energy requirements must come from oil. Coal output will increase by about ½ per cent a year, but it cannot keep pace with the growth of demand for energy. Any increase beyond this rate would involve a ruinous level of investment and an impractical increase in prices.

The idea that nuclear power arrived in the nick of time to prevent the industries of Europe grinding to a stop for lack of energy is regarded as a myth by Mr. Loudon. By 1975 its contribution is likely to be the 7 per cent forecast by OEEC, but certainly not above 10 per cent. And atomic power will be relatively expensive to produce. Capital costs, which are more important here than running costs, work out at two to three times more per unit of energy than in conventional coal or oil-fired power stations. Also atomic power is chiefly a method of producing electricity. So far it has not been used as a motive power except in United States navy submarines. The various energy sources are in fact complementary, not competitive.

Coal Piled High

The National Coal Board is going to require financial assistance from the Government to carry its undistributed stocks over into the new financial year. Stocks at pit heads and at open cast sites are estimated to be worth £67 million. Legislation will be necessary in order to let the NCB have these carry-over facilities but the Government is not likely to raise serious objections to this step being taken. At the moment the capacity of the industry is being increased while its output is reduced.

The problem is not unique for the United Kingdom coal industry. A similar stock prob-

lem has become critical on the Continent. A meeting was called last week by the Belgian Government to persuade other member-countries of the European Coal and Steel Community that a crisis had arisen. If this crisis can be accepted by the Council of Ministers of ECSC, the High Authority would be able to stop imports of coal and impose output restrictions. Belgium, Germany and France among them have stocks amounting to about 20 million tons but the problem is less acute in a sense in France where a large proportion of the stocks are of low-grade coal.

The High Authority has been opposed to its members accepting output restrictions along with high prices. It favours a solution along the lines of diverting underground labour from production to development work, a common policy of competition with fuel oil and a voluntary co-ordination of import policy. However, the bold and slightly ruthless talk in ECSC about cutting coal prices as yet finds no echo in the United Kingdom coal industry.

Fuel from the Unburnable

The Ministry of Power have inaugurated the first Lurgi high-pressure complete gasification plant in Great Britain at Westfield, Fife. The main contractors for the plant are Humphreys and Glasgow Limited, who will provide the generators in conjunction with the Power-Gas Corporation Limited and the German company which originated the process. The plant is estimated to cost £6·6 million and with the associated grid system the total cost will be about £8·5 million.

The ultimate capacity of the plant will be 30 million cu. ft of gas a day, equivalent to about one-fifth of the total Scottish gas consumption. The first stage, giving half the projected output, is due to be completed by the autumn of 1960 and in the meantime a medium-pressure and a high-pressure grid system is to be laid to distribute the gas through Perth and Angus to the north-east and through Kinross, Fife and Stirlingshire to Lanarkshire in the south-west and to the Lothians. Apart from the anticipated reduction in the cost of gas production the new plant is of particular importance in that it enables low-grade high-ash coals to be used for gas manufacture in place of high-quality gas coals which are in increasingly short supply. The calorific value of the gas after purification will be just over 400 B.t.u. per cu. ft but this will be increased to 425 B.t.u. by the addition of butane from the Grangemouth petroleum refinery.

Coal supplies are to be obtained by conveyor from the Westfield opencast site, the largest opencast coal operation to be planned in this country. The reserves are estimated at 25 million tons, sufficient to keep the site active for more than 20 years, and a contract for this period has been arranged between the National Coal Board and the Scottish Gas Board for the supply of the Westfield plant. An interesting feature of the development of the site is that the southern part is low lying, subject to flooding and the overburden consists mainly of peat. It was decided that the best way to remove the peat was by dredging and pumping it to the disposal area. An artificial lake was formed on which the dredge was floated. When the site is worked out the southern part will be restored to agricultural use but in the north a loch is to be formed.

Bonfire and Plot

The Government has made a bonfire of controls. The first batch was set alight when remaining HP controls were abolished, thereby freeing motor cars, radio and television receivers, other domestic electric and gas appliances, office furniture and fittings, aircraft and ships, from the Board of Trade Orders affecting hire-purchase credit sales and rental transactions. By doing this, the Government clearly indicate that they are now concerned about the employment situation. They wish to see the economy stimulated, so far as this can be done without an inflationary increase in incomes, by encouraging buying. In the past, a modification in HP controls has had a quick impact on sales of consumer goods.

More recently the Chancellor has announced that state investment, now running at about £1,425 m. per annum, will be increased next year by about £125 to £150 m., spread very widely and including railways, roads, hospitals and education. This investment of public monies is designed to counteract the recent fall in private investment.

The other measure of decontrol has a stronger political flavour. The new Emergency Laws (Repeal) Bill introduced last week is intended to prevent any Government in the future from enforcing wide economic control without parliamentary sanction. In other words, the path to Socialism if it is ever taken is to be a thorny and dialectic one by means of legislation. A number of economic controls (including those over hire purchase) are retained under Defence Regulation 55 but among those for burning are the trading powers of the Ministry of Supply and the authority of the Industrial Disputes Tribunal. The Government has found a convenient way of enshrining the excellent principle of specific parliamentary powers for specific purposes while rolling an obstacle in front of HM Opposition's future plans. This interference with the programme of some future Government hangs partly on the somewhat debatable point that the original powers were granted in and for a wartime emergency. Personal liberty has, however, triumphed over parliamentary convention, good as that convention may be.

Compensation at Market Value

The new Town and Country Planning Bill sets out to remove the dual valuation of land according to whether it is sold privately or to a public authority. This dual valuation arises from the failure of the 1947 attempt to vest in the State all development values subsequent to that date. If an owner developed land or sold land privately, he was liable to pay to the State the "betterment" value in excess of the developed value in 1957; if he sold to a public authority he would be paid the current undeveloped value plus whatever development value the land had in 1947. For private transactions the system was abandoned in 1954 as unworkable and thereafter the price received in a private sale included any development value which might have accrued since 1947.

While the price paid by a public authority prior to the introduction of the new Bill might in a few cases be higher than that for a private sale, it was usually considerably lower. The new Bill aims to remove the hardship suffered by owners of land subject to compulsory acquisition and in future the price to be paid in such cases will be "the amount which the land if sold in the open market by a willing seller might be expected to realise." There remains, however, one qualification which may give rise to difficulties in interpretation, namely that the willing buyer is to be assumed to know what planning permission would be granted.

The main objection to the payment of development value has always been that if an area is developed by a local authority this immediately increases the value of surrounding land and the authority has to pay dearly for any extension of the development. The Government appears to be anxious to provide some protection against this, but it has been questioned whether the safeguards are adequate and whether it will be possible to determine equitably in each case what is the development for which planning permission might reasonably be expected to be granted. Some clarification of these points may, however, be expected in the Committee stage of the Bill.

Letters to the Editor

SHAW'S ALPHABET

SIR, Mr. Pitman has issued a challenge, which I would accept by doubling the stakes if I thought it proper to join him in asking you to permit discussion in the debased currency of the tele-quiz.

Floored by my application of Parkinson's Law in the demolition of a Shavian economic fallacy, Mr. Pitman clutches at the loose straw which I intended for the apparent succour of a sinking polemicist; he attempts to turn my deliberate mistake into a red herring.

Of course one cannot render any passage of elegant prose into Basic English, nor basic English—nor indeed into Plain Words, the term I would have used in any other forum to connote a concise mode of expression. Writing in response to a gambit of Capricorn, I felt that this allusion to Gowers might not have been correctly taken, by the perfunctory reader, or even mis-read as deprecatory of Capricorn's other usage. The deliberate mistake was to write Basic for basic, and I am surprised that a phonetician of Mr. Pitman's standing should have fallen to so simple a trap. The need for both the upper and the lower case destroys half the argument for a fully phonetic alphabet.

Having exposed one of Shaw's obscurantist delusions, I now turn to another. He made much of the so-called phonetic script which he practised; but perhaps he never had occasion to write:

". . . if a woodcutter would cut wood."

Had he done so he would, as a faithful adherent to the precept of his Twentieth Century Manual, and Key, have used different symbols for wood and would, one phonetic, the other hieroglyphic. Like Sir Isaac Pitman's system of shorthand, English orthography is a fine example of the happy marriage of the phonetic symbol with the hieroglyph.

Sir, I shall be only to happy to allocate, to your nominated charity, a tithe of any award allowed me by the Shaw Trustees for helping you to project the light of reason and analysis into an airy-fairy-land of philological speculation.

Yours faithfully,

E. H. BATEMAN.

Sandyridge,
Upper Bourne,
Farnham, Surrey.
1 November, 1958.

INDUSTRIAL PNEUMATICS

SIR, Mr. F. X. Kay's clear and concise article "Some Basic Features of Industrial Pneumatics" reaches its climax with the words: ". . . for a machine which is to have a great number of separate functions, it is not surprising that a circuit full of interlocking pilots and pilot relays results." (ENGRG., 24 Oct., '58, p. 546.)

The patented Nickols sequence control system has been developed for automatic turret lathes and complicated special-purpose machines which, otherwise, can quickly resemble the inside of a mighty Wurlitzer organ if conventional pneumatic valves and circuits are employed.

One of our sequence control panels, with plug leads set for elaborate machine operation, is shown in the accompanying illustration. One solenoid valve controls each separate machine function, and standardised valves can thus be held in the works stores ready for any type of application. The required sequence is quite simply set on the panel by means of plug leads, and a multi-bank stepping switch selects the functions in any order or combination. Each step is successively triggered off by a pre-selected micro switch, time delay, automatic sizing device, or any other signal means, and all kinds of fool-proof interlocks can easily be arranged as required.

This control system is primarily designed for machines where flexibility and ease of change-

Obituary

SIR WILLIAM HALCROW

Yet one more of the few remaining links with the great civil engineers of the 19th century has been broken by the death of Sir William Halcrow. Sir William began his career as a pupil in the firm of Thomas Meik and Sons, which had been founded in 1866—some records say 1865, under the guidance of the then senior partner, Patrick Walter Meik. Later, in 1921, he joined the younger brother, Charles Scott Meik, as a partner and the firm became known as C. S. Meik and Halcrow; subsequently it was to be Sir William Halcrow and Partners, one of the largest—probably one of the two largest—operating from the United Kingdom. As a firm they "specialise" in dock and harbour engineering, railways, dams, tunnels and hydro-electric schemes, power stations and heavy foundations: everything, in fact, save major bridges—an omission shared by the other large firm of British civil engineering consultants, Sir Alexander Gibb and Partners.

William Thomson Halcrow was born on 4 July, 1883, and died at his home in Folkestone on Friday 31 August, at the age of 75. He was educated at George Watson's College and Edinburgh University before being articled to Mr. Meik. Following his pupilage he acted for the firm as an assistant and, later, resident engineer on works in Spain and Italy as well as one of the earliest water-power schemes in Scotland, that at Kinlochleven. For some years he extended his experience by serving, as chief engineer, the contracting firm of Topham, Jones and Railton. His first major work in this capacity was the graving dock at Singapore. During the war he returned to this country to take charge of the construction of the submarine defences at Invergordon and Scapa Flow. In the following year he returned to the Far East as agent in charge of building the Johore Causeway and Ship Lock. In 1921 he returned to consulting. The parallels between his career and that of the late Sir Alexander Gibb, who died earlier this year, are marked, though Halcrow did not have the generations of engineering forebears that Gibb succeeded. There are, however, the corresponding periods of contracting experience on major harbour works and naval defences before and during the 1914-18 War before beginning as consultant in the early twenties, though Halcrow joined an established firm whereas Gibb founded one.

From the beginning of his renewed connection with Mr. C. S. Meik the partnership undertook the design and supervision of major works and Halcrow assumed full responsibility upon the death of Meik in 1923. Among their early projects were improvements at the port of Beira, Mozambique, and the Lochaber power scheme which involved the construction of a 15-mile long pressure tunnel to bring water from Lochs Laggan and Treig under Ben Nevis to the British Aluminium Company's works at Fort William.

He was also consulting engineer to the Grampian Hydroelectric Company for works which included 14 miles of tunnels and many dams, and later engineer for the Caledonian and Glen Affric water-power projects. As consulting engineer for the London Passenger Transport Board's tube railways (jointly with the late Sir H. H. Dalrymple Hay—whom he also succeeded as consulting engineer to the GPO) he carried out the extensions of the Bakerloo line to Finchley Road and of the Highgate line to East Finchley, and he also designed the flood-protection works on the underground railways.

His work on official committees and panels was enormous. During the last war his work included deep tunnel shelters for the Ministry of Home Security and munitions factories for the Ministry of Supply. He was a member of the War Cabinet Engineering Advisory Committee and chairman of the panel of engineers who designed the Mulberry harbour. Among the great projects upon which he reported were the Severn Barrage tidal power scheme, the River Volta hydro-electric scheme and the Tema harbour in Ghana, and the Kariba and Karfue hydro-electric projects in the Rhodesias. He was or had been member of the Advisory Council of DSIR, the Royal Fine Art Commission and was Honorary Consulting Engineer to the War Graves Commission. He was knighted in 1944.

He was a past-President of the Institution of Civil Engineers. When he delivered his address in November, 1946, he departed somewhat from precedent—not for the only time in his life—by saying nothing of the particular branch of engineering to which his professional life had been devoted. He took the opportunity to review the progress of the Institution and stressed the importance of the engineering professions speaking with one voice. He decried the growth in the number of engineering institutions and advocated a greater support of the Engineering Joint Council. Sir William was a past-Chairman of the Association of Consulting Engineers and a past-President of the British section of the Société des Ingenieurs Civils de France.

Continuing

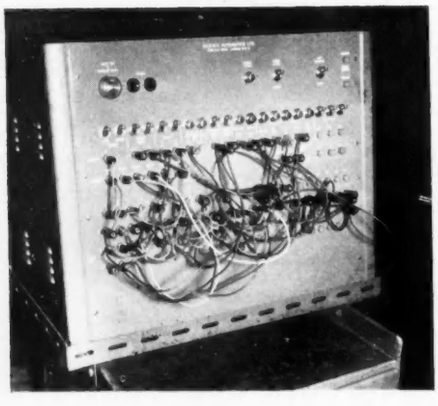
Letters to the Editor

over is important, any sequence being quickly available without need for altering valves and pipeline connections; but our equipment also appears to simplify the layout of many single purpose machines even though they may be designed to perform the same work unceasingly for several years.

Yours faithfully,

IAN NICKOLS.

Nickols Automatics Limited,
7 Carlisle Road,
London, N.W.9
27 October, 1958.



Nickols sequence control panel with plug leads set for machine operation.

Editor's Note: Mr. Kay has drawn attention to the fact that in Fig. 8 (p. 546) of his article, referred to in the above letter, the lever of valve 11 is drawn in the "stop" position, whereas the valve is shown in error in the "operate" position.

DR. S. LIVINGSTON SMITH, C.B.E.

On Monday, 27 October last there occurred the death of Stanley Livingston Smith, Director of Research for the British Shipbuilding Research Association, and vice-President of the Institution of Naval Architects—one of the best known figures in the field of marine engineering. Born on 9 September, 1889, at Southend-on-Sea, where he received his early education, he entered the City and Guilds College in 1906 and graduated in 1909. Practical training followed at the Thames Ironworks, Shipbuilding and Engineering Company Limited; his first appointment was as an inspecting engineer for the Crown Agents.

An academic career, begun when he joined the teaching staff of the City and Guilds College, was interrupted by the First World War. Under the Royal Society War Committee, Dr. Smith conducted secret experimental research and also served as an Engineer Officer in the Royal Air Force, taking charge of the Marine Training and Manning department. At the end of the war he returned to the College under Professor Dalby and was appointed Assistant Professor in 1926. In 1931 he was made Reader in Mechanical Engineering for the University of London, having the degrees of M.Sc. and D.Sc. conferred on him in recognition of the research work he carried out. This position he held until 1939, becoming a familiar and respected figure to a generation of students. About this time also he was appointed by the University as Chief Engineering Inspector of Technical Institutions, and there must be many who recall his visits and constructive comments. He also represented the Imperial College on the Surrey County Council Education Committee.

In 1939 Dr. Smith was appointed Superintendent of the Engineering Department of the National Physical Laboratory, a post that kept him fully occupied with research projects during the Second World War. He served on many of the defence committees set up during those days—the full list would be a long one. He represented the DSIR on several research associations, the Industrial Health Advisory Committee and the Agricultural Development Board. In 1940 he was elected a Fellow of the City and Guilds of London Institute.

After five years as Superintendent at NPL, Dr. Smith became the first Director of Research of the British Shipbuilding Research Association, very shortly after that body had been incorporated, and this post he held till the time of his death. Under his direction the Association was established as the central research organisation for the shipbuilding, ship-repairing and marine engineering industry in the United Kingdom, carrying out work on many problems. As he had done before, Dr. Smith served on a great number of committees, among which may be mentioned the Froude Ship Research sub-committee of the NPL, Admiralty committees on the application of nuclear power to marine purposes and structural steel, the corrosion committee of the BISRA and the research board of Pametrada. He was also a member of Lloyds technical committee and a director of Power Jets Limited. In acknowledgment of his great contribution to the engineering in general and to shipbuilding in particular, he was awarded the CBE in the 1951 New Years honours list. He was a member of the Institution of Civil Engineers and the Institute of Marine Engineers. He also served on the Council of the Institution of Mechanical Engineers and at one time was a vice-President of the Institution.

Plant and Equipment

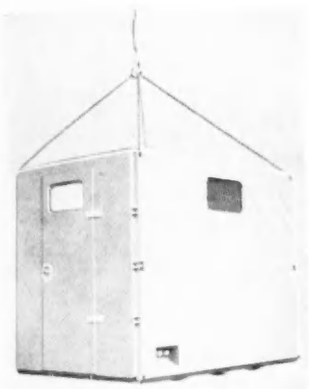
DUST FREE ASSEMBLY

Those many assemblies, common nowadays, which require to be carried out in a dust free atmosphere, present a problem to the manufacturer. One solution is the use of special cabinets in which the assembly is performed and which have some means of excluding dust. One such is the pressurised cabinet made by John Bass Limited and marketed by B.M.B. (Sales) Limited, Boscobel, High Street, Crawley, Sussex. These leave the hands free from sealing gloves by supplying a stream of filtered air flowing from inside out. One model is shown in the illustration.

Power is supplied by a 0·08 h.p. motor which passes air across a heater (either 1 or ½ kW according to model) and then through a filter. The latter can be of various types with limits of 5 microns or 2 microns. Inside the cabinet is a 60 or 75 watt strip light, again according to size. The de luxe model has a thermostat temperature control and both have a manometer to show the filter efficiency. The overall sizes of the larger are 36 in long by 20 in high (at the back), and the cabinets can be arranged for either pedestal mounting, as shown, or for standing on a bench. There is also another series which is sealed and operates under vacuum.

A stream of filtered air renders the interior of the cabinet free from dust for fine assembly work.

AIR TRANSPORT CONTAINERS



Displayed at the Farnborough Air Show were Aircon containers made by Airtech Limited, Haddenham, Buckinghamshire; one is shown on the illustration. Overall dimensions can be varied to suit requirements but a typical example is 9 ft by 6 ft by 7 ft high which, when made in mild steel, weighs 1,050 lb. Alternatively they can be made in aluminium. The payload is from 3 to 6 times the tare weight.

The containers are insulated with a 2 in thick layer and the interior panelling is hardboard, but this can also be chosen to suit particular requirements. The end walls can be either fixed or detachable. For movement on highways they can be fitted with a wheeled chassis with retractable pneumatic tyred wheels or they can be mounted on castor wheels or skids. The containers can be fitted with heating and ventilating systems and some models are designed for dropping by helicopter.

The Aircon containers can be transported by air as complete units for telephone exchanges or living accommodation.

REPLACING SUNSHINE

Irradiation cabinets for the group therapy of factory and underground workers are now being made by " V " Development Limited, 22 Clifton Road, London, W.9. Their purpose is to replace sunshine and so improve the standard of health and reduce absenteeism. The cabinets are fitted between the washing and dressing rooms so that the men pass through them slowly; an average radiation time of 4 minutes is envisaged, starting with 2 min per day and increasing to a maximum of 10 min. Treatment should only be on every second or third day. The cabinets measure 12 in by 14 in by 67 in and weigh 40 lb. There are four Neron lamps in each arranged to irradiate both sides of the man passing through.

BALL BEARING HISTORY

A very early example of the use of ball bearings was recently exhibited at London Airport in the form of a bicycle of 1852 which had ball bearing pedals made by Frederich Fischer. It was from supplying bearings for his father's bicycles that he later established the factory at Schweinfurt in Germany in 1883, and developed an automatic manufacturing process. In company with the 1852 cycle were shown a modern Raleigh Superb cycle, a Bentley and a Viscount 802.

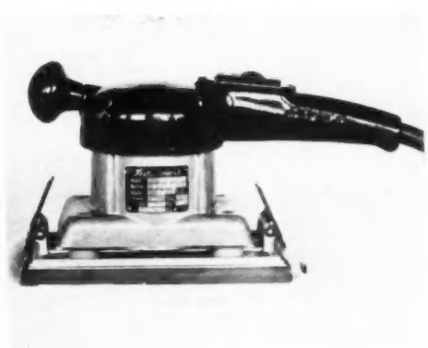
VEHICLE GAS TURBINE

A recent report from the Ford Motor Company gives some details of the progress made in the production of a gas turbine for use in road vehicles. The Ford 702 engine undergoing development at Dearborn, Michigan, develops 160 h.p. and has hauled loads up to 32,000 lb when fitted in a truck and tried on the test track. This included hills of 17 and 30 per cent.

There is a single-stage compressor feeding the combustion chamber. Air temperature after compression is about 400° F and after combustion is about 1,500° F at the turbine inlet. There are two turbine wheels, one driving the compressor and the other the transmission of the vehicle; after expansion the gases are at about 1,000° F. They exhaust through a heat exchanger placed between the compressor and the combustion chamber, increasing the inlet air temperature to about 900° F and at the same time being themselves cooled to about 500° F, passing out to atmosphere at nearly the same temperature as a normal petrol engine exhaust. It is also stated that a cheaper way has been found for making the turbine wheels.

INDUSTRIAL SANDER

The Festo straight line sander is a heavy-duty industrial hand tool marketed by Guillet, Sons and Company Limited, 28/30 Rivington Street, London, E.C.2. Particular claims are that it is the first straight line sander not to use belts, and that by sanding along the grain of the wood a better finish with freedom from circular scratching is obtained, facilitating subsequent french polishing. The pad is driven positively, but without belts or gears, from a squirrel cage motor; there is a long working stroke combined with a large sanding pad to give high cutting power. The tool is insulated for 2,000 volts.



The Festo industrial sander has a straight line action.

Continuing **Plant and Equipment**

Preview of the Public Works Exhibition

PLANT *for the* CONTRACTOR

THE diesel engine (with torque converter where appropriate) is now used exclusively as the power unit on civil engineering plant; the petrol engine—because of high fuel charges—has disappeared, the electric drive is only occasionally convenient, and the gas-turbine has yet to arrive for general application. Continuous concrete mixers are fast replacing batching machines (even with built-in measuring equipment). Vibrating rollers and flat-plate compactors are available in a full range of sizes. Flexible drives to small tools have almost completely given way to rotary air drives. The tractor shovel—which, with a dozer blade, is able to combine most of the duties of a medium-size excavator and bull-dozer—is now the general purpose machine used on many construction sites.

These are some of the trends which will be confirmed at the Public Works Exhibition when it opens next week on Monday, 10 November.

The equipment which, if exhibited, would be most sought after by contractors includes improved weighing machines for the smaller concrete mixers; better spreaders in road-laying machines for both concrete and stone in tar macadam roads (formwork itself is no longer the sole limitation to obtaining a good surface); bigger air systems for handling pressurised cement on site; faster-moving crawler tractors to off-set the speed advantage of rubber-tyred tractors; and a standardised 7 to 9 ton lorry at a reasonable price to replace the familiar 5 ton run-abouts (at the present the price tag jumps too far for the slightly heavier, more robust job). These are some of the things which, if they appear at the Exhibition, are assured of a successful reception.

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The seventh Public Works and Municipal Services Congress and Exhibition to be held since the war will be held at Olympia from 10 to 15 November. Around 400 exhibitors will provide a comprehensive display of machinery, plant and equipment required by civil engineering contractors, builders and municipal authorities. Simultaneously with the exhibition 22 papers will be read at the five-day congress. Though, as is to be expected, they are mainly concerned with issues for the municipal engineer, among those of a wider interest are "Water Conservancy: a World Problem," by Sir Eric Rideal; "Water Supply in Retrospect and Prospect," by Mr. J. Noel Wood; "Problems of Trade Waste Disposal," by Dr. F. J. L. Meinck of Berlin; "Recent Developments in Plant and Appliances Used in Public Works," by Mr. R. U. Law; and "Implications of Design and Construction of Highway Bridges due to Standardisation," by Mr. Alan S. Whitaker.

This year, for the first time, it will be possible to buy plant by hire purchase actually in Olympia, and the recent relaxation in hire purchase controls may bring some brisk business. Three finance houses—United Dominions Trust Limited, London, E.C.3; Lombank Limited, London, W.1; and Forward Trust Limited, Birmingham—have taken space in the Empire Hall Gallery. They will consider the provision of credit facilities for the completion of public works contracts and for the renewal or modernisation of machinery and equipment.

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The following notes on tractors and dumper trucks are based on some of the information sent to us by manufacturers in advance of the Exhibition; or on facts taken from the official guide and catalogue. Reference to concrete-making and placing equipment and compressed air plant is omitted completely and held over for treatment in a later article since some significant improvements seem to be taking place on which the manufacturer's pre-Exhibition blurbs do less than justice; the assessment can wait till the plant has been seen. Bearing in mind the growth that there is at the present time in the use of timber for industrial building there looks like being surprisingly little information on the subject at the Exhibition. Secondly, though most plant can be employed equally well on railway work as road work, most manufacturers seem to have their eyes on the road programme rather than the £1,200 million railway modernisation plans; though much of this sum is to be spent on capital works, most manufacturers seem bent on ignoring the railways.

Nearly all plant and equipment seems to have reached a fair level of design such that a constant working period can be relied upon between overhauls and about a 10 per cent turn down has to be allowed for maintenance. For duties of any particular severity—for example, such as may be undertaken by tractor shovels—there is an appropriate make of plant that will give good service. If the job to be done is a heavy one, then there is a heavy machine available—at a price.

Several different bodies are made for this AEC "Dumptruk," according to the material to be transported. ACV Sales Limited.

The "Big Ben" Dumper truck has an all-steel body of 15 cu. yd capacity. Thornycroft Limited.

After-sales service is becoming good. It is not only on the multi-million pound motorways that equipment manufacturers will establish a spares depot on site. The civil engineering industry is becoming more mechanised; its permanent labour force has become highly skilled. The unskilled labourer is still employed—he is still the weak point of the industry—but he is disappearing fast.

On the roads side it is of course the new trunk roads—particularly the motorways—that are in the news. It should not be forgotten, however, that the bulk of money spent on roads will always be on maintenance, repairs and improvements. Fortunately, the Ministry of Transport took the view that the new London to Birmingham motorway should be built at high speed; the contractors, John Laing and Son, are showing that it can be done. Now that the lesson that speedy construction buys economy has been learnt, it is to be hoped that the same maxim will be applied to road maintenance and improvement jobs. As as has been said in these columns before, it would be better to close even a major thoroughfare for a short while and let the contractor get on with the work uninterruptedly than, as is so often the case, expect road surfaces to be laid piecemeal over many months while single-lane traffic limps by. Collectively, road engineers have a lot to learn from railway engineers about undertaking maintenance and improvements while keeping traffic on the move.

An overloader—one of the few—to be designed around a crawler tractor, the 70 h.p. Fiat. Mackay Industrial Equipment, Limited.

The Loadmaster 3000 has a bucket capacity of 10,000 lb and does 26 m.p.h. Chaseside Engineering Company.

The smaller overloaders also make excellent plant for snow clearing. Weatherill Limited.

Engines

Apart from the engines exhibited indirectly, already installed in plant, a number of makers will be having displays principally comprising engines and accessories, the power output ranging upwards from about 1½ h.p. of the air-cooled model on the stand of R. A. Lister and Company Limited, Dursley, Gloucester. The largest air-cooled model on this stand is rated at 30 h.p. and the water-cooled engines have outputs ranging between 5 and 70 h.p. On the same stand Blackstone engines are to be shown of up to 1,320 b.h.p. Perhaps the longest range of engines will be shown on the several stands of firms belonging to the Hawker Siddeley group. Mirrlees, Bickerton and Day Limited, Stockport, will exhibit a diesel developing 864 h.p. at 450 r.p.m.; at the other end of the range will be the high-speed air-cooled diesels of small capacity built by Petters Limited, Staines.

On the stand of Rolls-Royce Limited emphasis is to be laid on the interchangeability of components required for a range of models having outputs of between 60 and 600 b.h.p. Anyone fitting Rolls-Royce engines throughout will have solved at least the problem of spares. The range has been designed to cover all " heavy " applications met in public works. All the engines are able to supply full power from either end of the crankshaft and any model can be fitted with a variety of flywheels and flywheel housings, exhaust and manifold arrangements, and other accessories.

The 8-cylinder RR turbocharged engine developing 400 b.h.p. (gross) at 2,100 r.p.m. is fitted in the new Aveling Barford SN dumper—claimed to be the most powerful British-built dump truck in the market. Also to be exhibited are the turboblown 6-cylinder engines developing 300 b.h.p. at 2,100 r.p.m. as are fitted in the Foden FR6/45 dumper and the 6-cylinder supercharged engines used in the Euclid 22 ton dump trucks. Crawler tractors will be represented by the new International Harvester and the Vickers Vigor.

A long range of air-cooled diesel engines will be found on the stand of Ruston and Hornsby Limited, Lincoln. The outputs vary from 4 to 110 b.h.p. and the particular virtue claimed for them is their sustained efficiency in all extremes of temperature and climate. The exhibits include engines arranged for automotive purposes and as standard industrial packs, particularly with improved dust protection suitable for use with stone crushers. In addition there will also be 6-cylinder " excavator " pack—the 210 h.p. water-cooled model with torque converter used in the Ruston-Bucyrus excavators.

Participating at the Exhibition for the first time is the Cummins Engine Company Limited, Shotts, Lanarkshire. Though the company have only recently become established on this side of the Atlantic they are able to claim that already many European equipment and vehicle manufacturers are offering models powered by British-built Cummins engines. Four engines are to be exhibited, all 6-cylinder models; three of them produce maximum torques of 490, 825 and 900 lb-ft respectively, the first two being naturally aspirated and the third turbocharged.

The fourth engine on the stand will be sectioned to show off the basic design and construction features. All the models, as are all Cummins engines, are fitted with the maker's PT fuel pump and injection system. The particular claim made for this system is its simplicity so that (nearly) any mechanic can understand and service it with little training. The full range of the maker's engines include naturally aspirated and supercharged engines of 150 to 335 b.h.p.

A small-capacity four-stroke petrol engine will make its debut on the stand of Villiers Engineering Company Limited. This is the Mark 7/1, a unit of 74·6 cc with a 1·2 b.h.p. rating at a shaft speed of 3,600 r.p.m. The engine has a bore of 50 mm and a stroke of 38 mm. A compact unit, the engine can be equipped with 3-1 reduction gear and with a mechanical or air-vane governor. There is also a choice of oil-wetted or oil-bath air cleaner and either rope-and-pulley or recoil starting. Weighing only 31 lb, it is equipped with a Villiers B.10 carburettor and a 2-pint fuel tank.

For the first time at this exhibition the Villiers display will include JAP engines. The current Villiers-JAP range starts with a 34 cc two-stroke unit developing ¼ b.h.p. and rises through regular capacity stages to an 824 cc twin-cylinder four-stroke engine with a 15 b.h.p. rating.

Dumper Trucks

High-capacity, heavy duty dumper trucks are the natural corollary of big earth-moving equipment. They find their maximum use on the opencast coal sites where not merely are the loads heavy but where they operate over a road-system having restricted access to the public so that high speeds are permitted (demanded even by the operators). Those contractors who have bought them have found them a very economic proposition.

The only vehicle that will be on the stand of Fodens Limited will be their new dumper truck which has a payload of 56,000 lb (25 tons) or 18 cu. yd. It is fitted with a Rolls-Royce turbo-blown diesel developing 300 b.h.p. and torque converter, and the three-speed gearbox enables it to reach a maximum speed of 24 m.p.h. (the single reverse speed has a theoretical maximum of 12 m.p.h.). The rear axle has been designed specially for dumper duty, incorporating a spiral bevel reduction unit and differential in the centre and a reduction gear in the wheel hubs. Air brakes operate on all four wheels and the hand brake, mounted directly behind the gearbox, has a disc diameter of 20 in. Tyres normally fitted by the maker are 18·00 × 25 — 28 ply Rocklug with single wheels at the front and doubles at the rear.

The body of the dumper has a struck capacity of 18 cu. yd and the main framework consists of 7 in by 5 in pressed steel channel; the floor is of

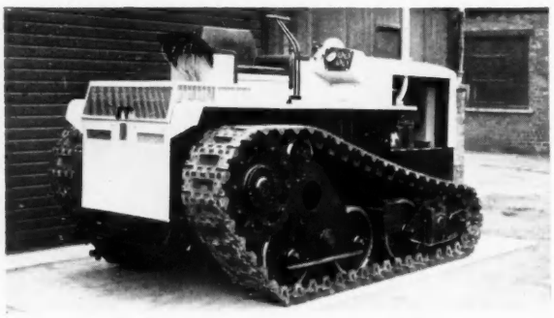
Continuing Plant and Equipment

½ in steel plate and the sides $\frac{5}{16}$ in plate. All the plate is of a toughened abrasion-resistant steel but when rock is to be transported an alternative floor is available reinforced by inverted 3 in by 3 in angle sections. A protective canopy extends over the driver's cab which is fully enclosed and slightly off-set to suit the left-hand controls.

Nearby on the stands of the Aveling-Barford group of companies will be an even larger dumper truck than the Foden. This is the new " SN " dumper which has a payload of 27 tons (18 cu. yd struck). The power unit is a Rolls-Royce 8-cylinder turbocharged engine of 400 h.p. The makers claim that it is the most powerful dumper available in this country and, further, say that its power to weight ratio is unequalled by any other of the world's dumper manufacturers. Also on the stand are two smaller models, one of 4 tons, and the other of 2 tons capacity; both have diesel engines fitted.

A smaller machine is the " Dumptruk " exhibited by ACV Sales Limited, Southall, Middlesex. The new model, fitted with an AEC 11·3 litre diesel engine developing 150 b.h.p. at 1,800 r.p.m., includes many features developed during recent years experience of off-the-road activities. There is now a basic design available with a number of alternative bodies. The general-purpose body has $\frac{3}{16}$ in plate on the sides over a deep-pressed steel frame and the floor is of 2 in hardwood sandwich; it has a capacity of 10 cu. yd. A 20° scow-gate rear is fitted and the cab-protection canopy extends right over the cab. Alternative widths of 7 ft 10 in and 8 ft 4 in to suit on or off the road working are available. A " rock " body of $\frac{3}{8}$ in plate and 8 cu. yd capacity is made for shifting stone or rock. For the bulk transport of coal an 18 cu. yd body in $\frac{1}{4}$ in plate and sandwich floor 1 in thick is built; in this case a tail door replaces the scow end and only a short cab-protection canopy is fitted. For all versions, a detachable hydraulically-controlled scraper blade is available as an extra. The operating weight of the complete vehicle varies from 10 tons 6 cwt with the coal-carrying body to 11 tons 1 cwt with the " rock " body; the maximum gross weight is 24 tons.

Tractor-mounted excavator and trencher; general-purpose machine for small contractor. Thos. Ward Limited.



Prototype of the new BB.90 tractor with improved crawler track suspension. W. G. Bagnall Limited.

Yet another dumper truck is that on the stand of Thornycroft Limited, Smith Square, London, S.W.1—their " Big Ben " 15 cu. yd model on a chassis with a 13 ft 6 in wheelbase. This also has a 6-cylinder 11·3 litre engine, but rated slightly higher at 155 h.p. at 1,900 r.p.m. The all-steel body is 16 ft long from top of sloping front to end of scow; the inside body width tapers 6 in from a front width of 8 ft 6 in and is 3 ft 9 in deep with 6 in wall slopes. The floor is of laminated construction with 2 in of hardboard filling between two $\frac{1}{4}$ in steel plates. Double-acting hydraulic rams operating in conjunction with a mechanical linkage give an angle of tip of 70° and an approximate tipping time of 10 to 12 seconds; the powered return takes 8 sec.

Tractor Shovels

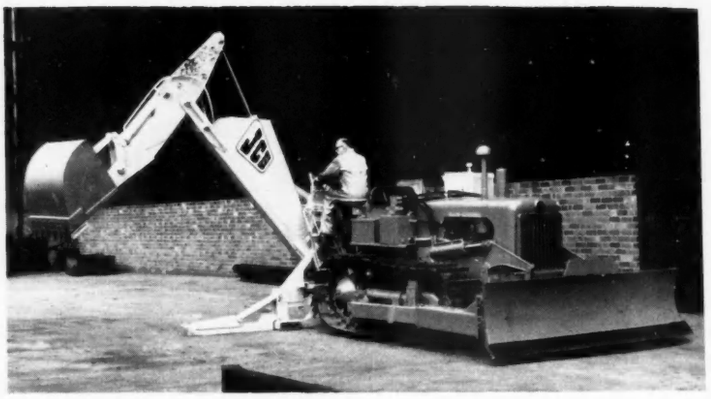
The point has already been made that the tractor shovel has become the most widely used piece of plant on contractors' sites. The majority of models available are built around standard tractors, either crawler-track mounted or on wheels. The choice between the mountings is the issue between the high-speed working of wheels against the ability of the tracks to keep going over sticky surfaces. If the working surface is firm (or, when bad, is so bad that nothing can operate on it—as is met overseas) then there is much in favour of the rubber-tyred tractor; on the other hand, for the United Kingdom, the crawler tractor can keep working for a longer time in deteriorating conditions. Most manufacturers, however—and contractors presumably—seem to prefer tyres, relying on four-wheel drives to get out of soft spots and the faster working more than compensating for stood-off time.

In choice of tractor shovel the prospective buyer is as well served as for any item of plant; there is everything from small lightweight models (inexpensive) to heavy robust machines (with matching price tag). Claimed to be the largest machine of its type built in Great Britain is the Michigan 275A. Powered by a 265 h.p. Cummins diesel the machine has a top speed, both forward or in reverse, of 28 m.p.h. The heaped capacity of the bucket is 4 cu. yd and the lifting capacity of the machine is 22,000 lb to a dumping height of 9 ft 6 in. Necessarily the 275A is big: 24 ft 8 in maximum length, 10 ft 3 in width over tyres and 12 ft to top of the cab; but there is not much that it will not shift. Smaller tractor shovels will also be shown on the same stand, in particular the 85A, which has a capacity of 9,000 lb and is designed about a 92 h.p. Leyland engine.

More typical of the British built machine are those that will be seen on the stands of the Bray Construction Equipment Limited, Feltham, and Weatherill Limited, Welwyn Garden City. These are much smaller machines built around engines of 50 or 60 h.p. and well suited to work on building sites; local councils have found them excellent for snow clearing. In both cases these machines have four-wheeled drives and good dumping heights—12 ft for the Weatherill " Hydraulic."

Somewhat larger is the Loadmaster 3000, which will be on the stand of the Chaseside Engineering Company Limited, Hertford. It has a fully automatic transmission with torque converter and drive through all four wheels (which are of equal size). Powered by a 148 h.p. engine, it has a payload of 10,000 lb and a top speed of 27 m.p.h.

One of the few crawler-mounted tractor shovels is the Allis-Chalmers HD.6G which will be among the equipment on the stand of Mackay Industrial Equipment, Feltham. The engine has net engine horse-power of 72; at the drawbar the capacity is 57·3 h.p. with a maximum pull of 15,970 lb. Standard equipment includes a 1½ cu. yd two-position bucket which enables the operator to choose either the general-purpose dig position or a tip-back position, depending on the job conditions and the material being handled.



Much smaller, but also track mounted, is the Fiat FL.4 tractor shovel which will be making its first appearance at the exhibition on Mackay's stand. It is powered by a four-stroke Fiat diesel developing 35 h.p. and is fitted with a ¾ cu. yd tipback bucket; at the rear there is a useful ripping tool. The dumping height of 7 ft 4 in is low for general purpose work and, as is to be expected with tracked vehicles, the maximum speed is only 5½ m.p.h. On the other hand, at a weight of under 4 tons it will keep working longer than its wheeled rivals.

Crawler Tractors

Reputed to be the world's fastest crawler tractor—its top operating speed is 9·7 m.p.h.—is the Vickers Vigor which will be shown on the stand of Jack Olding and Company Limited, Hatfield. Manufactured by Vickers-Armstrongs (Tractors) Limited, the Vigor is powered by the supercharged 6-cylinder Rolls-Royce diesel engine developing 200 h.p. Operation experience has shown the machine to be one of the best of its kind ever built in this country: the biggest difficulty is sales inertia whereby users go on buying from the same firms as before—and the Vigor was not the first in the field. Also on the stand will be a matching Onions open-bowl scraper and an angle-tilting dozer, as well as the smaller Vickers Vikon, which is based on the 4-cylinder RR engine of 142 h.p., and a Wakefield medium duty motor grader.

The prototype of a new heavy tractor, equipped with hyro-static transmission and a novel form of track suspension, will be on the stand of W. G. Bagnall Limited, Stafford. Designed by Mr. John S. Burns

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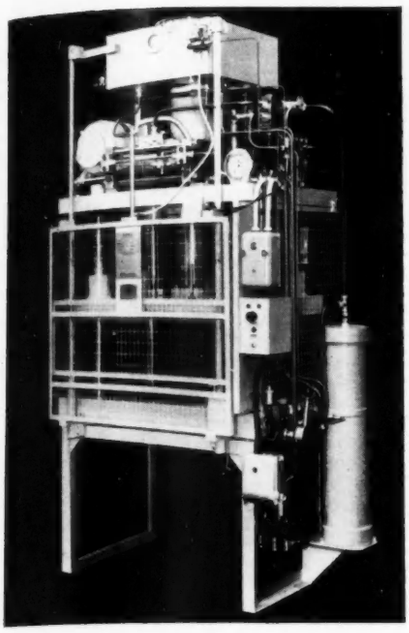
Continuing **Plant and Equipment**



FLASH CLIPPING PRESS

A semi-automatic downstroking flash clipping press has been produced by British Industrial Plastics Limited, Tat Bank House, Oldbury, Birmingham, for use with moulding presses in the plastics industry.

The press has an overall height of under 9 ft, is 4 ft 7 in wide, with a depth of 3 ft 4 in. The bottom table is fixed and stands 26 in clear of the floor on angle iron side legs. The tables are designed to accommodate 30 in square bolsters and in the bottom table there is an 18 in square hole, centrally situated, for ejection purposes. The maximum daylight available is 26 in, with a minimum of 14 in.

The press can be supplied entirely self-contained or for use with a Bipel central drive unit. The pressure range is of 10, 20 or 30 tons from the 1,000 lb per sq. in feed supply upon the main ram of 6 in diameter. This range is achieved by using the Bipel continuously-reciprocating intensifier, which can be set for either 2 : 1 or 3 : 1 intensification of the supply. The range can be varied throughout by use of a reducing valve in the main circuit. The intensifier is not brought into use until the pressure on the main ram has reached approximately 750 lb per sq. in.

The main ram is of the annulus head type with a 14 in stroke and a push back load of 1·86 tons. In order to achieve a fast cycling time, two accelerator rams, each of 1¼ in diameter, are used to assist in closing and the two rams have a constant feed supply. The ram heads are all fitted with Wellworthy cast iron piston rings and the cylinder bores in which they operate are precision honed. The rams are hard chromium-plated and ground and fitted with U-section seals.

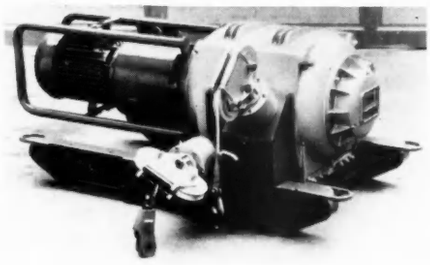
The press has a free run speed of approximately 600 in per minute and a full tonnage working speed of 40 in per minute. The distance over which the working pressure is applied can be adjusted by means of a slow close valve, operated by a cam attached to the rear of the press which also governs the rate of approach.

30 ton flash clipping press for plastics.

ANTARCTIC COMPRESSOR

Compressed air for drilling the holes required during the construction of Scott Base for the recent trans-Antarctic expedition was supplied by a Hydrovane compressor made by Alfred Bullows and Sons Limited, Long Street, Walsall, Staffs. The compressor was driven from the power take-off on a Ferguson tractor. The holes were drilled with a rotary diamond-tipped tool and the chippings removed by a blast of air. A ¾ in rod with a nut on the lower end was then inserted in the hole and water added to fill it up. The water, of course, froze and so made the anchorages for the buildings and radio masts. Air was also used for conventional percussion drills and spades. The average summer temperature during which most of the work was done was between 15 and 20° F.

HAULAGE WINCH



A range of "Puller" winch units for haulage purposes is now available from ACE Machinery Limited, Porden Road, Brixton, London, S.W.2. One is shown in the accompanying illustration. They are particularly suitable for use with a scraper bucket or drag for working on stockpiles. The rope drums can be arranged singly or in series and are driven by totally enclosed motors through reduction gearing. Multi-plate electromagnetic clutches are used. Spring-loaded shoe-type brakes can be set for operating in either direction. The motors are normally for 440 V 3 phase supply.

The winch unit can be used to operate scraper shovels for stockpiling.

Continuing **Plant for the Contractor**

and to be known as the Bagnall-Burns BB.90, it is powered by a Meadows 4DC420 engine, weighs 8 tons, has a rated draw-bar pull of 15,000 lb and a top speed of 7 m.p.h. in both directions. It is illustrated on the previous page.

The transmission is based on positive-displacement oil pumps driving positive-displacement motors and it is claimed that the number of principal components and controls in this machine is markedly less than in conventional tractor drives.

The track suspension is designed to eliminate slack or over-load in the tracks when moving over rough ground. Each track is carried by a pair of independent articulated bogies, the leading ones each carrying an unsprung supporting idler above the bogie wheel and adjacent to the drive sprocket which is remote from the ground. This arrangement permits compensating adjustment in the upper run of the track for variation in the lower part as the bogies oscillate as the tractor moves over uneven ground, thereby giving maximum driving contact whatever the condition of the surface. The main frame has been designed for the easy fitting of the usual run of matching equipment—dozer blades, loaders and diggers.

Also among the new tractors will be the Challenger 33 made by John Fowler and Company (Leeds) Limited and exhibited on the stand of their associates, Marshall, Sons and Company Limited, Gainsborough. The engine in this machine is the 125 h.p. Leyland; its top speed is 6·2 m.p.h. and the fuel consumption is 4 gallons per hour under normal working conditions. A particular feature of the Challenger tractors is the "three-piece" track rollers which have replaceable wearing paths and are fully sealed with face-type seals. Matched equipment, also made within the Marshall group, comprises hydraulic angledozer and a cable-control unit.

To be shown for the first time at any major exhibition is the Track-Marshall J.C.B. Trencher which will be on the stand of Thos. W. Ward Limited, Sheffield. Also illustrated on page 596, the machine is a combination of the Track-Marshall crawler tractor and the J.C.B. Hydra-Digga. Wards claim that the result is a useful tool which will appeal to the smaller contractor. The tractor is driven by a 50 h.p. Perkins giving a drawbar pull of 12,100 lb, six forward speeds from 1·31 m.p.h. to 5·15 m.p.h. and two reverse speeds. In addition to the trenching tool the machine will be shown fitted with a hydraulic angle-dozer.

The J.C.B. Hydra-Digga attachment is designed for trenching, ditching, hole-digging and face-shovelling. The pull at the lip of the bucket is a minimum of 20,000 lb. The A-frame allows the main boom to be rotated through 180° and the digging depth is 13 ft; the dumping height is 10 ft 8 in—sufficient for most lorries and dumpers. A range of trenching buckets from 6 in to 52 in wide is available with an alternative forward-acting face shovel of 9 cu. ft. This machine possesses the feature lacking on most conventional tractor shovels—the ability to trench.

Companies in the News

Switch to Devon

Demand for electrical switchgear has declined sharply in recent months, along with the demand for machine tools and other items of capital equipment. Nevertheless, one company, Ottermill Switchgear Limited, continues to expand. Eight years after their move from Acton to Ottery St. Mary, Devon, they have increased their labour force from 80 to 203 and recently completed extensions to their factory.

At the official opening of the new premises the Member of Parliament for Honiton, Robert Mathew, quoted the success story of Ottermill Switchgear as an incentive to other light industries to settle in East Devon. A member of the company's staff commented on the very much improved working conditions in Devon as compared to London; none wanted to return to industrial areas and most of the " emigrants "—mainly draughtsmen—appeared to be well satisfied with the " clean air, pleasant surroundings (a fine view over the Otter valley and the Devon hills), better light and a quieter way of life."

French electrical equipment manufacturers are doing rather better than their British competitors. The largest of them, Compagnie Electro-Mécanique—some of whose switchgear equipment is made in Wolverhampton by Contactor Switchgear—recorded a turnover of Frs 38,350 million in 1957, an increase of 17 per cent over the previous year's turnover, and the order book figure " continues to improve." This company's record suggests that French industry has still to feel the main impact of the developing world recession.

Courtaulds Recover

The interim statement by the directors of Courtaulds Limited suggests that an improvement has taken place in the demand for man-made fibres. Although trading profits during the first half of the current financial year (ending 31 March, 1959) have been less than those for the corresponding period of last year, there are " in certain directions signs of the improvement for which hopes were expressed in the statement by the chairman given to the AGM on 16 July last ". Profits for the year are not now expected to show any further fall.

Reports from Lancashire indicate that there is a slow but encouraging expansion of demand for man-made fibres. Acetate and nylon filament yarns in particular are making a good recovery. This is timely, for British Nylon Spinners (in which Courtaulds have a 50:50 holding with ICI) are currently well below last year's level.

Courtaulds' plans for diversifying their activities are going ahead. The oil cracking plant at the Spondon, Derby, factory of British Celanese is to be expanded by some 40 per cent of present capacity. The plant produces ethylene and propylene and from these a wide range of petrochemicals. Work has already begun and completion is expected within 9 to 12 months. The expansion will incorporate a very extensive use of automatic control and recording apparatus. This plant, which began operating in 1942, was the first in the United Kingdom to produce alcohols and petrochemicals by the cracking process.

Fireproof Cables

The difficulties of the cable industry do not unduly inhibit one of the latest and most successful entrants. Pyrotenax Limited, who have made considerable advances in the design of mineral-insulated metal-covered cables, are making a public issue of ordinary stock. They are in a strong position to attract the necessary capital. Trading profits have risen steadily since 1949, from £95,000 to £728,000 in 1958. The only setback was experienced in 1954 when profits fell by £52,000 to £306,000. Net assets total £1·26 million and prospects appear to be very sound. The demand for their products continues to be well maintained both at home and overseas, although competition has recently become more pronounced. Nonetheless, sales to date are higher than last year and there is " no indication of any falling off in the volume of business."

Pyrotenax electric cables are specially suitable for ships, aircraft, chemical works, nuclear power plants as well as in factories and housing. The main patents expired in 1954 (when the company was converted into a public company) and in 1956. Other patents, relating to improvements and new processes, are still in force and the trade mark rights remain.

The company have expanded substantially overseas in the 22 years of existence. Subsidiary companies were founded in Australia, New Zealand and Canada, and the parent company have a third share in a syndicate known as " Association en Participation pour le Developpement du Pyrotenax aux USA." In this country they employ about 700 people mainly at their Hebburn-on-Tyne factory and head office.

Pump Surge

Sigmund Pumps Limited are the third well-known pump manufacturers to be taken over in recent months, following the acquisition of Pulsometer Engineering Company by Philip Hill, Higginson and Company, the merchant bankers, and that of Hayward Tyler and Company by Platt Bros. (Holdings). In this instance it is the molasses company, Booker Brothers, McConnell and Company, who are the purchasers through their subsidiary Bookers Engineering Holdings. Ninety per cent of the share capital has been acquired from the Sigmund family and from the Industrial and Commercial Finance Corporation. Mr. Miroslav Sigmund, the Managing Director of Sigmund Pumps, retains a ten per cent interest in the company and remains managing director.

Sigmund Pumps began the foundations of their present range of pumps after the war and quickly achieved pre-eminence in the centrifugal pump field, investing heavily in research and development and producing a wide range of new designs. Subsequently they acquired a number of manufacturing licences from overseas and established themselves in other fields. Through the production of a Swiss design for hot-water circulation, the Cuenod glandless pump, and its further development, Sigmund have played a leading part in the development of the small-bore forced-circulation heating system which is bringing central heating within the reach of every household in the country.

The burden of research and development costs, so essential in a fast developing business of this kind, became progressively harder to bear and increased supplies of working capital essential. The membership of the Booker Group should enable Sigmunds to continue their progress and is an important step in the expansion of the engineering interests of the group.

Blaw Knox Chemical Engineering

A new company has been formed jointly by Blaw Knox Limited and their American associates, Blaw-Knox Company of Pittsburgh, Pa., to " design, engineer, procure and erect process plants as well as process equipment for the chemical and petroleum industries and serve and develop the British and overseas markets." The company, Blaw Knox Chemical Engineering Company Limited, will have their registered offices at 90/94 Brompton Road, London.

The announcement by Blaw Knox Limited pointed out that this was a logical development following growing demands for their consultations, design, engineering and construction services. The new company will be able to draw upon the experience and knowledge of the Chemical Plants and Buflovak Equipment divisions of Blaw-Knox, Pittsburgh. They have an extensive background in the design of plant for general industrial chemicals, resins and plastics, caustic and chlorine, petro-chemicals, food processing, pharmaceuticals, fats and oils, etc. The Buflovak Equipment division's products include evaporators, drying equipment, flakers, autoclaves and pressure vessels and special designs of process equipment. The research and testing laboratories of Blaw-Knox, Pittsburgh, will be available to Blaw Knox Chemical Engineering for customers' product research.

Future plans call for a two-way exchange of ideas and reports on scientific and engineering developments, which will enable the companies to maintain close touch with world-wide technological development. The managing director of BKCE Company will be Mr. John Woade, a graduate of the university of Colorado, who joined Blaw-Knox, Pittsburgh, in 1956.

Petrol and Gasoline Get Together

The British Petroleum company announce that they have agreed in principle with Sinclair Oil Corporation to develop a programme of joint action on the American continent. This includes a long-term supply agreement covering Sinclair's United States domestic requirements for Middle East crudes produced by BP in the Persian Gulf area; the establishment of a jointly owned company to engage primarily in the marketing of Middle East and Venezuelan crudes in the Western Hemisphere; and the establishment of another jointly owned company to provide for exploration and production ventures primarily in Latin America.

The joint programme has been under study for some time and has been evolved as being " particularly well fitted to the two companies' positions, which are in many ways complementary." BP are one of the largest producers and marketers of petroleum and petroleum products in the Eastern Hemisphere and Sinclair a substantial producer and marketer in the Western Hemisphere.

Kestner Distillate

The Kestner Evaporator and Engineering Company Limited, have just celebrated their fiftieth anniversary, with the founder, J. Arthur Reavell, in the chair. Mr. Reavell started the company in 1908 with the late Paul Kestner, who had himself founded his office in Lille in 1902 and made available his original patents and techniques to the British company. Nineteen years later he converted his business in Lille into a company, Appareils et Evaporateurs Kestner, and entered into an agreement with the British company whereby they would " furnish to each other full particulars and information as to tests and experiments on evaporators and all technical and other information and data relating to the evaporation and/or concentration of liquid."

The British company successfully developed a number of different drying systems—spray driers, TV (thermo-venturi) driers and infra-red driers—and also their heating systems by the Merrill and isoelectric processes. On their side, the French company passed on to KEE their process for manufacturing phospheric acid, recent improvements in ammonium sulphate, for the regeneration of spinning bath liquors from the manufacture of artificial silk and on various items of plant. The latter included glandless vertical pumps, submerged and helicoidal pumps, " autolaveurs " and " stato-laveurs " for gas washing and Dowtherm heating.

This interesting story is told most attractively in the Kestner Golden Jubilee book, which is a useful document for all those interested in the ways and means of making foreign manufacturing licence agreements work smoothly.

The Human Element

Unions Clean House

There have been distinct signs over the last week that the trade union movement is going to do something about "unofficial" troublemakers. The British trade-union movement is a very British institution for all the fiery words that have come out of it in the last hundred years. It has a strong sense of fair play and a respect for minorities. It loves the way of compromise and except at times of emotional tension it is notably conservative in attitude. It has a good deal of common sense and is not a little lazy—all of which adds up to the average Briton's attitude.

Last week it showed indications of stirring itself against humbug from within, especially from the Communist cells. In Sheffield there was an uproar at a district meeting of the AEU about unconstitutional activities of the Communist cell there and the official organisers were not afraid to wash a little linen in public. At the Shell site in London the Amalgamated Union of Building Trade Workers took disciplinary action against members who had fomented the trouble and the Amalgamated Society of Woodworkers have advised their members that the group who organised the trouble in London are not to be supported in organising a "rank and file" conference. In the London Airport court of inquiry proceedings the union officials have won a good deal of favourable publicity against the unofficial leaders. The next and more difficult step is to increase the interest of union members in the activities of their union work.

Safe than Sorry

The importance of the work done by the Ministry of Labour's factory inspectors relating to industrial health has been underlined by the publication for the first time this year of a separate report, *Annual Report of the Chief Inspector of Factories on Industrial Health*. The general review of the year's work describes the progress made in preparing new legislation, and in the two industrial health surveys (in the town of Halifax and in the pottery industry in Stoke-on-Trent) undertaken with the advice of the Industrial Health Advisory Committee. The Halifax survey was published last year—*Industrial Health; a Survey in Halifax, HMSO, 1s 6d*—and arrangements have been made for the survey team to approach occupiers of factories in Halifax where more than 250 people were employed, "with a view to interesting them in the advantages of the provision or extension of medical and nursing services."

The industrial health survey of the pottery industry, which involved visiting 298 establishments in North Staffordshire, was completed by the end of last year and a report is being prepared. A reference is also made to the Inspectorate's efforts to raise the general standard of facilities for first-aid in factories, and to improve the supply and quality of first-aiders. Among the industrial problems currently being investigated include "noise in industry," in co-operation with the Medical Research Council, the Department of Industrial and Scientific Research and other bodies. "Dust and fumes in foundries" and "dust in cardrooms" are other subjects under investigation.

Visitor from India

An eminent Indian engineer is spending two months in this country at the invitation of the British Council. His object is to get first hand knowledge of British methods of training engineers—from courses at technical colleges to university degree work including sandwich courses. He is Professor Janaki Ram, vice-principal of the Birla Institute of Technology, professor of mechanical and aeronautical engineering and a member of the engineering faculty at Bihar university.

Professor Ram is closely concerned with future policy in training India's engineers, as member of the Board of Studies in Engineering. In London, Professor Ram will visit the City and Guilds College, Brunel College of Technology, Regent Street Polytechnic, Cranfield College of Aeronautics, the Royal Aircraft Establishment Technical College, and Battersea Polytechnic. He will meet the youth employment officer of the London County Council, the education officer of the Institution of Mechanical Engineers, and officers of the Ministry of Labour.

Dachshund or Dinosaur

The German trade union federation is trying to have a law passed which will prevent the growth of monopolies. The incident which has touched this off is the decision of the Mannesmann organisation to undo the decentralisation of control carried out by the Allies after the war. The unions' attitude is of interest for two reasons.

First of all, size does not spell efficiency in many cases. In the past much has been written and said about the economic power of the big German combines, not least in the export field. Much of this power was in fact the other side of British weakness rather than a proof of German strength—the weakness of the British chemical industry before the first world war being a case in point. On balance the Germans have probably lost at least as much by creating large combines as they have gained, for such structures are big but unwieldy and are apt to become the dinosaurs of industrial evolution, dying out for lack of adaptability.

Second, the German unions are moving in the opposite direction to British unions, which hanker after large groupings—largely because they are easier to nationalise or bargain with. Bigness begets docility and a willingness to ally itself with organised labour against the customer so far as price is concerned. The Germans seem to want small units of management because they fear the economic power of the big combines. They have perhaps still to learn the cynical lesson which British union officials absorbed long ago, namely, that it is easier to prod a well-conditioned elephant in the direction you want it to go than a herd of smaller animals.

International Finishing School

The exchange of students between the 24 member countries of IAESTE—the International Association for the Exchange of Students for Technical Experience—declined last year for the first time since its foundation 11 years ago. The reasons for this decline of 540 to 5,394 was stated to be the deteriorating economic situation in many of the member countries. Britain, France and Italy received even more students than the previous year, but Finland, Germany and particularly Sweden substantially less.

IAESTE's annual report contains a most detailed statistical picture of student exchange. Since its foundation, 39,996 students have been provided with industrial, agricultural or economical training in countries other than their own. In spite of the decrease in the numbers of the students this year, there is evidence that this "finishing school" for industry is receiving wider backing. The number of industries collaborating with IAESTE has increased and attempts are being made to widen this support further. A tour has been planned, with UNESCO support, of countries in South Asia and North Africa to investigate the possibilities for increased exchanges.

So far, most of the exchanges have been between relatively few countries, both for sending and receiving. Austria, Finland, Germany, France, Britain, the Netherlands and Sweden accounted for over 70 per cent of the total number of students received and for nearly 80 per cent of students sent. There is obviously a need for a wider spread of IAESTE's activites, to make an appreciable impact on underdeveloped countries planning industrialisation.

Looking After Number One

The number of workers covered under staff life insurance and pension schemes continues to increase. At the end of last year over 3 million employees were covered under schemes insured with the life offices, an increase of 310,000 compared with 1956. Their annual premiums totalled £155 million, which had secured prospective pensions of £464 million a year.

The information is contained in a report published by the Life Officers' Association and the Associated Scottish Life Offices, entitled *British Life Assurance Statistics* 1953-57. It reveals the considerable importance attached in this country to the kind of "compulsory" saving which an insurance policy constitutes. Over half a million people last year were involved in new occupational schemes. There is a similar development among self-employed people, following the special provisions made under the Finance Act, 1956, to free certain forms of annuity contracts from tax liability. By the end of last year some 71,000 of these contracts had been effected, securing future pension benefits of nearly £23 million a year.

An analysis of the life offices' investments show a continuation of the trend for Government securities to form a small proportion of the total, and equities a larger proportion. The pace of this movement, however, is diminishing. The present division of investment is 28 per cent in Government stock, 22 per cent in debenture and preference issues, 17½ per cent in equities, 17 per cent in real estate and 15½ per cent in mortgages.

Fire Below

It has been noticeable in the last few years how a zeal for encouraging safety measures has led to a form of excess. Road accident posters and industrial accident themes have played up fear, sometimes in rather tasteless forms. The notorious "black widow" poster has had a large progeny.

The latest example of this comes from Lancashire where the Palatinate has been set alight in more senses than one by a publicity stunt for November the Fifth. Burning nightdresses made of synthetic materials has been called for as part of the "Plot" celebrations by the County Council to draw the public's attention to the dangers of allowing such garments to get near flames. The local manufacturers of such garments have been indignant about the whole affair. The Cotton Board with admirable phlegm has stated that if people burn their nighties it is bound to be good for business. The excess of zeal on one hand is balanced by a sense of humour on the other.

This particular example of enthusiasm for safety will probably do good on balance because it has received some publicity and most people will laugh at it. They may therefore also remember. It is certainly an improvement on trying to teach the elements of precaution by frightening people. Disarmament exhibitions got nowhere before the war by playing up the horrors of mutilation. The lesson should be applied in this age to the safety problem. Furbelows aflame may not aptly commemorate Guy Fawkes' attempt to set politicians alight, and is more likely to bring a sparkle to the eyes than fear to the heart.

Third in a Series of Consolidated Reports On t

PROPULSION

By

B. T. PRICE, M.A.

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It is sometimes difficult even for those most closely concerned to appreciate how fast nuclear technology is being pushed forward. At the time of the 1955 Geneva atomic conference only one ship—the Nautilus—had ever put to sea on nuclear power, while nuclear merchant ships were still only in the planning stage. Now, only three years later, six American submarines have been launched; seven more are under construction; the Nautilus and Skate have cruised under the polar ice-cap; and the Sea-Wolf has spent 60 days submerged. All these, of course, are military activities, and are hardly appropriate for discussion at a Conference on the Peaceful Uses of Atomic Energy. But in addition, the Russian nuclear-propelled icebreaker Lenin has been launched, and the mixed cargo-passenger liner Savannah is under construction in America. At the same time a great deal of thought has gone into the economic possibilities of nuclear propulsion, so that there is now a considerable measure of international agreement regarding the uses to which nuclear ships will be put, and the time-scale within which they may be expected to become economic. This rapid progress was represented at the second Geneva conference by reports from the designers of the Lenin and the Savannah, and by summaries of project studies which have been carried out in a number of other countries.

Soviet Union

It is difficult to imagine a more suitable application for nuclear power than the icebreaker Lenin which is nearing completion in Russia. Existing conventional icebreakers need frequent bunkering and cannot make use of the whole 6,000 miles of Russia's northern coastline; but with the much greater endurance of the nuclear icebreaker this becomes possible. It is worth paying almost any price to ensure the continuity of navigation, and for this reason conventional economics have not concerned the designers of the Lenin, shown in Fig. 1.

The Lenin is a ship of 16,000 tons, with a length of 440 ft and a beam of 91 ft. Her engines total 44,000 h.p., and give her a speed of 18 knots in clear water. She is able to operate at full power without the need for refuelling for one year, corresponding to several years' actual sea-time. Her ratio of installed power to width along the water-line is nearly twice that of the next most powerful icebreaker, and enables her to maintain a continuous cruising speed of 2 knots in ice 8 ft thick. She has three screws, the centre screw (which is best protected from ice) having a capacity twice that of each outboard screw. Special attention has been paid to obtaining maximum thrust while running at low speed in ice, and it is expected that a thrust of 330 tons will be developed. The ship has an extremely small turning circle diameter of just over three hull lengths.

In the design of the mechanical plant, safety and reliability are the main requirements. The need to use enriched uranium for the three pressurised-water reactors is no disadvantage for this application, especially as the cost of even conventional icebreakers is very considerably raised by the difficulty of supplying large quantities of fuel to them under arctic conditions. From the point of view of reducing weight and size it is, of course, best to have one reactor delivering the whole power requirement of the ship. The Russian philosophy (as stated in paper P2140[1]) is that, for the sake of reliability, a ship should have not less than two reactors, and in the Lenin no less than three have been provided. The reserve reactor virtually overcomes the problem of xenon poisoning.

The reactor core has a diameter of 1 meter and a height of 1·6 metres. The coolant flow through the core follows normal practice in being a double-pass system. Each reactor generates 90 MW (heat), and the maximum thermal flux is 10^6 kilocal per sq. m per hr. Fuel is uranium dioxide (UO_2) canned in zirconium, and the core contains about 85 kg of uranium 235. A burnable poison (boron) is included in the centre group of fuel elements to ease control problems and to give a measure of flux flattening. Slow reactivity changes due to poisoning, burnup and fission-product formation are partly compensated by rods which are semi-transparent to neutrons, and which can be adjusted in order to give the desired heat distribution in the core.

United States

A considerable amount has already been published about the Savannah, and the two American papers did not contain any surprises, though they filled in some details. Paper P1831,[2] by W. H. Zinn and R. B. Godwin,

Fig. 1 An icebreaker, such as the Soviet Union's Lenin, represents an ideal early application of nuclear power to marine propulsion. The high cost of installing and operating the vessel's three reactors is justified by the importance of ensuring continuous navigation along Russia's northern coastline.

GENEVA DISTILLATE

Prolific in papers and enormous in scope, the Second International Conference on the Peaceful Uses of Atomic Energy can only assume its true significance when the information presented there has been thoroughly digested. As a stage in this process, ENGINEERING has commissioned fourteen specialists to summarise the matter of the Conference under a number of subject headings. The process may be regarded as one of distillation, with concentrated fractions drawn off at various levels. The contributors have consolidated the information published during the Conference, selecting the essentials, reconciling the submissions of different authors and countries, and tabulating the most important data. As an introduction to the series, we published on 19 September Sir John Cockcroft's overall survey of the Conference. The present series is being published roughly at weekly intervals and will include thirteen articles in accordance with the accompanying table. The Conference was held in Geneva and lasted from 1 to 13 September.

Power Reactors	Mr. G. W. K. Ford, Research Manager, Dounreay
Research Reactors	Dr. V. S. Crocker, Reactor Division, Harwell
Thermonuclear Research: (Pinch Effect)	Dr. A. A. Ware, AEI Research Laboratory
(Other Devices)	Dr. R. J. Bickerton, Controlled Thermonuclear Research Division, Harwell
Propulsion	Mr. B. T. Price, Reactor Division, Harwell
Radiation Shielding (31 October, page 568)	Mr. J. D. Jones, Reactor Division, Harwell
Engineering	Mr. R. P. Kinsey, Chief Engineer, Advanced Reactor Design Office, Risley
Metallurgy	Mr. L. M. Wyatt, Technical Manager, Central Technical Services, Research and Development Division, Risley
Instrumentation	Mr. R. B. Stephens, Mullard Equipment Ltd.
Nuclear Physics (24 October, page 536)	Dr. M. J. Poole, Nuclear Physics Division, Harwell Dr. M. Sowerby, Nuclear Physics Division, Harwell
Applications of Radioisotopes	Mr. E. R. Wiblin, Isotope Division, Harwell
Isotope Separation	Dr. H. Kronberger, Director, Research and Development, Risley
Chemistry and Processing	Dr. R. Hurst, Director, Dounreay

On the 1958 Geneva Atomic Energy Conference

gives a general description of the ship, and some details of estimated future trends in the operating costs of nuclear ships. The Savannah will have a length of 595 ft, and a displacement of 21,840 tons. She will carry between 60 and 100 passengers, and will have a cargo deadweight capacity of 9,400 tons. A single PWR unit will provide 22,000 s.h.p. which will give the ship a service speed of 20 knots. The location of the reactor in the hull may be seen from Fig. 2. Fig. 3 shows cans for a prototype fuel assembly being developed in connection with the Savannah; long fuel rods clad in stainless steel will be inserted in the cans.

Unlike an ice-breaker, propulsion of a cargo-passenger liner by nuclear power rarely offers the shipowner any special advantages over propulsion by oil. It is true that the total weight of the reactor installation is somewhat smaller than the weight of conventional machinery plus fuel for a long voyage; but the differences are not such as to swing the balance strongly in favour of the nuclear ship. The great range of the nuclear ship—the principal feature of the Lenin—is of importance for only very few shipping routes, particularly as oil bunkering facilities are widely distributed throughout the world. Nuclear power for passenger or cargo ships is therefore attractive to the shipowner only if it costs less than conventional power. Because of the way nuclear and conventional power costs vary with the size of the unit, nuclear power is most nearly competitive when the power requirement is large. However, even for the largest ships there does not seem to be any immediate application for nuclear power, though by 1965 Zinn and Godwin estimate that the freightage cost per ton of crude oil for a very large (100,000 ton) tanker might be only 10 per cent above the best conventional cost. The paper gives some figures for the capital and fuel costs for rather smaller ships, in the 20,000 to 40,000 ton range; but here the conclusion seems inescapable, that even assuming the use of cheap enriched fuel, and allowing for improvements in nuclear technology, nuclear propulsion is unlikely to be competitive within the next 20 years.

One of the most useful by-products of the Savannah programme will be the testing of the reactions of port authorities throughout the world to nuclear powered ships. Partly for this reason, the reactor design is extremely conservative, even though this approach necessarily increases the capital and operating costs of the ship. The containment vessel which houses the whole of the primary circuit is 35 ft in diameter and 51 ft long. It is 2½ in thick and is designed to withstand both the pressure liberated during a sudden catastrophic rupture of the primary circuit and also any missiles resulting from such a rupture. The container is set well inboard, and is further protected from collision damage by two large collision mats formed of a sandwich of 1 in steel plates, spaced by timber. Bearing in mind that even the Stockholm, travelling at 20 knots, penetrated only 15 ft into the hull of the Andrea Doria, it is reasonable to expect that no conceivable collision could ruin the integrity of the containing vessel, protected as it is by concrete, wood, steel, and the heavy reinforced hull of the ship.

The primary circuit of the reactor in the Savannah follows the general lines already developed in America for land PWR stations. Primary coolant water at 1,750 lb per sq. in is circulated in two passes through the reactor core by two pairs of two-speed canned rotor pumps, and then through two shell-and-tube type steam generators. The primary circuit is made of type 304 stainless steel, and the same material is used to clad the carbon-steel pressure vessel. The pressure vessel is 26½ ft high, and a little over 8 ft in diameter. The core is roughly a cylinder of 61 in diameter and 66 in height, made up of 32 rectangular fuel elements, each 8·9 in square. Each element contains a bundle of 0·5 in diameter uranium dioxide (UO_2) pellets, clad in stainless-steel tubes. The enrichment of the fuel will be about 4 per cent. The core is designed for a long life between successive refuellings of 600 days at full power. This corresponds to roughly three years' operational service. To provide such a long life involves a large excess reactivity of 15 per cent in the cold clean condition at the start of the core life. There will be 21 cruciform-shaped boron steel control rods, with electro-mechanical top-mounted drive. The propulsion system will be conventional, except that it will use saturated steam at the low pressure of 415 lb per sq. in at 28½ in mercury vacuum. Emergency power for the ship's services, and take-home power (in the event of reactor failure) will be furnished by two 750 kW diesel generators, with an 850 h.p. take-home motor on the main reduction gears. The gross weight of the propulsion system and the reactor system are 1,150 and 600 tons respectively. The container and shielding weigh 1,900 tons, so that the total weight of the whole installation will be about 3,650 tons.

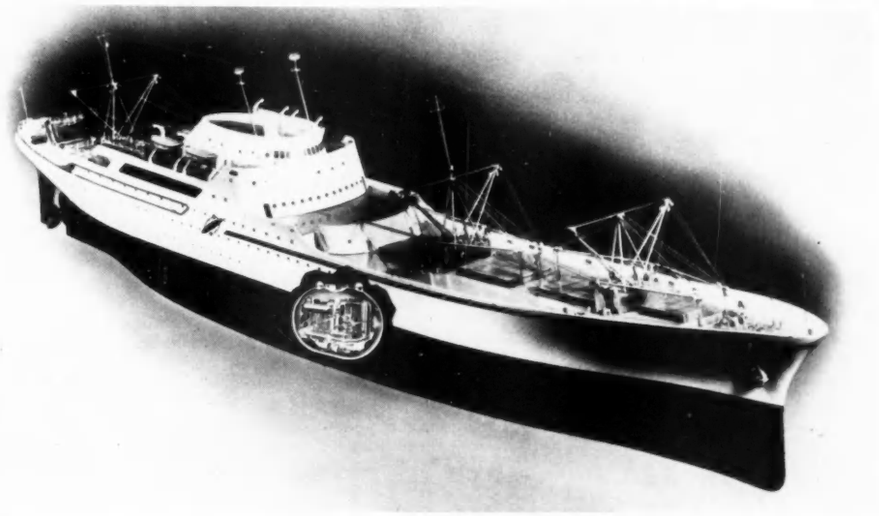


Fig. 2 (above) An impression of the American nuclear-powered merchant ship Savannah, now under construction.

Fig. 3 (right) Cans for the prototype fuel assembly being developed for the Savannah. Long fuel rods clad instainless steel will be inserted in these cans.

Further design details of the Savannah are given in paper P1023[3], by R. P. Godwin and D. L. Worf. This paper deals with passenger and crew radiation levels, shielding, containment, the handling of radioactive products, and a nuclear hazards analysis.

The permitted degree of exposure for everyone on board is very low. In all areas to which passengers have access the radiation levels will not exceed 0·5 rem per year, which is very little more than the intensity of naturally occuring cosmic and other radiations. It is also estimated that very few crew members will receive more than about 0·5 rem per year. The reactor operators may on occasion be subject to higher dose rates (for instance, when changing a filter in the primary circuit), but the maximum exposure of any individual member of the crew has been fixed at 5 rem per year.

One of the features of a nuclear ship which will be new to shipyards is the handling of radioactive effluent produced during normal operation. The designers of the Savannah have given considerable attention to this problem. Active corrosion products collected on filters and ion exchangers in the primary circuit, and coolant water which may be contaminated with fission products, will be contained in special apparatus provided on board. Small amounts of radioactive gases such as argon 41 will be discharged through the radar mast under controlled conditions. Radioactive waste will be jettisoned in the open sea, at a rate not exceeding 250 millicuries per mile steamed.

Continuing **Propulsion**

France

A French paper, P1137,[4] summarised some of the work that has been done since 1956 on behalf of the French Ministry of Transport. The specification was for a 40,000 ton dwt. tanker, propelled by a single screw delivering 18,000 to 20,000 s.h.p., and capable of operating on both long and short sea routes. The paper gives details of studies on pressurised water, boiling, and gas-cooled graphite-moderated reactors. It makes no discussion of economics, though it was stated during the oral presentation that nuclear power is already not far from being economic.

The PWR design employs a reactor fuelled with uranium oxide enriched to 1·5 per cent clad in zirconium. Control is by a conventional system of 21 cruciform rods. The choice between vertical and horizontal heat exchangers is discussed, and vertical units are selected because of their reduced size, lower weight, and easier replacement. Double-pass cooling in the reactor core is preferred, and it is stated that it reduces weight and is £250,000 cheaper than single-pass cooling. It is considered possible to arrange for emergency cooling by thermosyphon when the reactor is shut down. The insensitivity of the PWR to rolling and pitching, and its large negative temperature coefficient, are regarded as important safety factors.

The section on boiling reactors is largely concerned with an investigation of the effect of motion of the ship on the escape of steam bubbles, and hence on the reactivity and power of the reactor. It is shown that forced circulation in the primary circuit has a beneficial effect. The layout of the components is also important, since it influences the driving pressure heads. A study of the reactor kinetics shows that it is desirable to use a smaller steam to water ratio than could be tolerated ashore. The most important effect of the ship's motion is the vertical acceleration during rough weather, and a system of compensating for its effects is discussed.

The third section of the paper, on gas-cooled reactors, rejects as premature any system in which the reactor coolant gases pass directly into a gas turbine. The authors are clearly unwilling to contemplate the problems of servicing an active marine gas turbine. They prefer instead a two-circuit arrangement, in which fairly high-quality steam is raised in a heat exchanger. The reactor proposed is a straightforward extrapolation from French and British graphite-moderated carbon-dioxide cooled land-based reactors. However, to obtain the power of 60 MW (heat) and at the same time make the reactor small enough for use in a ship involves many compromises between economics, weight and safety. The resulting reactor has an overall height (including the loading dome) of 60 ft, and projects a little way above the deck.

Japan

Just as a nuclear ice-breaker exploits the great endurance of a nuclear reactor, so would a submarine cargo vessel exploit the reactor's independence of the atmosphere for consuming its fuel. A paper P1320,[5] by Michiya Shigemitsu, discusses a Japanese study of a nuclear-powered submarine tanker. The attraction of freighting cargo in submersible vessels instead of in surface ships comes from a lowered fuel cost, due to the absence of wave-making, freedom from storms, and reduced hull fouling. The savings resulting from the smaller power requirement will almost certainly be offset by a larger capital cost for the hull and propulsion plant, and it still has to be demonstrated whether on balance there remains any incentive to go below the surface. The paper does not deal with this point, but concentrates on technical feasibility.

In deciding the type of cargo to be carried, the need to keep hatch openings and projections on the hull to a minimum is probably decisive. This suggests that a submerged vessel would not be suitable for ordinary general cargo, but would be particularly adapted to liquid cargoes such as oil. An oil-tanker has the additional advantage that a good deal of the cargo space can be designed as a non-pressure-resisting structure; only a small part of the oil tanks, the reactor and machinery spaces, and the living quarters, need be capable of withstanding the full diving pressure. The design discussed is for a tanker with leading dimensions as given in Table I below. The form of the vessel is as near as possible that of a streamlined body of revolution, somewhat like an airship. The reactor would be of a PWR type, having a thermal output of 180 MW.

TABLE I.—*Leading Dimensions of Proposed 30,000 dwt. ton Submersible Tanker*

Length overall	590 ft
Breadth	79 ft
Depth amidships	79 ft
Displacement	48,200 metric tons
Mean draught (loaded)	56 ft
Cruising speed submerged	22 knots
Normal horse-power	2 × 20,000 s.h.p. (one reactor)

The main body of the paper is devoted to a discussion of the marine aspects of the work, particularly hull design. The authors estimate that for a 30,000 dwt. ton ship the hull weight is reduced by about 10 per cent compared with a surface vessel, and that this weight advantage in favour of the submarine is much more pronounced for larger ships.

It is a pity that a number of important practical points are not discussed. For instance, the authors do not mention the limitations on the operation of their submarine, due to its draft of 56 ft. Such a vessel could not use the Suez Canal, nor could it operate into many of the West European ports. Moreover, 30,000 ton dwt. is by no means large for a present-day tanker. It is a reasonable hope that within a few years it will be possible to take 65,000 ton

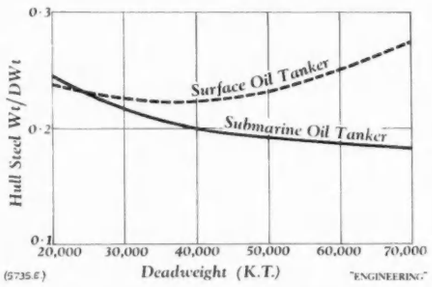


Fig. 4 Ratio of hull steel weight to cargo capacity for surface and submerged tankers.

surface tankers through the Suez Canal. But a 65,000 ton submersible tanker with a hull of circular cross-section (the best for underwater performance) would draw 72 ft, and would be unable even to enter the Solent. Large submarines of this capacity would therefore almost certainly have to be designed with an elliptical cross-section, to give the necessary cargo capacity without too great an increase in draft. The wetted area would then be increased, which would considerably reduce the power advantage resulting from submerged operation. A comparison between surface and submerged tankers appears in Fig. 4, which shows the ratio of hull steel weight to cargo capacity for the two classes of vessel.

A second Japanese paper, P1319,[6] by Takeuchi, Okamura, and Murakami, discusses a nuclear-powered immigrant ship. For many years South and Central America have received immigrants from Japan, and at present a regular service is maintained by five ships, with a total annual capacity of 8,000 passengers. The route on which these ships trade is one with few refuelling stations. Moreover, the cost of fuel oil in Japan is relatively high, owing to the distance from major oilfields. The authors consider the case of an immigrant ship propelled by a pressurised-water reactor generating 180 MW (heat), and compare the economics of nuclear and conventional vessels. The nuclear ship, freed from the necessity of calling at bunkering ports, can save about 10 per cent in distance steamed over a round trip. Moreover, its cargo capacity can be increased. Taking these factors into account the authors conclude that a nuclear-powered immigrant ship could already show a profit, though the percentage return on invested capital would be considerably less than with a conventional ship. These calculations assume that fuel will be available at the relatively cheap American prices, that only 4 per cent interest need be paid on fuel not actually consumed, and that a plutonium credit of $12 per gram will be obtainable. The authors' encouraging conclusions underline the influence which cheap enrichment and cheap money may have on the development of nuclear marine propulsion.

Great Britain

A paper by R. V. Moore and C. E. Iliffe, P266[7], "Nuclear Propulsion for Ships," discusses some of the general requirements which must be satisfied if nuclear ships are to attract the support of the marine industry. One potential advantage of the nuclear ship is the reduced weight of the propulsion machinery. For a conventional ship the weight of the bunkers must be added to the weight of the machinery. A nuclear ship has no bunkers, and in spite of its heavy shield can show a saving on long voyages. The most important single factor determining the weight of nuclear installations is the size of the reactor core. Graphite moderation gives the least compact core, water the most compact. On the other hand, somewhat higher enrichment may be needed for the light water core.

The paper discusses the modifications which must be made to the gas-cooled graphite-moderated type of reactor to fit it for marine use. The heat rating must go up, which means that the fuel must be more highly subdivided. Gas passages must be larger, and this results in extra neutron losses due to streaming. There may be some advantage in reducing the moderator-to-fuel volume ratio, and in changing from uranium metal fuel to uranium dioxide. A great deal depends on the temperatures at which the fuel elements can be run. If carbon dioxide is used as a coolant the chemical reaction between CO_2 and graphite may become serious with the introduction of higher heat ratings and temperatures. To investigate these and many other problems the Advanced Gas-Cooled Reactor Experiment is now being built.

A brief summary is given of an economic study on a nuclear-propelled supertanker. The authors estimate that at current oil prices the cost of transport of oil in a nuclear vessel of 45,000 dwt. would be about 14 per cent more than in a conventional vessel, and that this figure would be smaller for larger ships. Nuclear

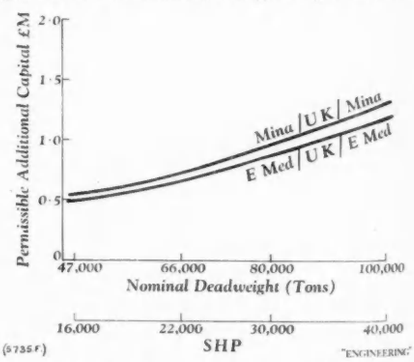


Fig. 5 Permissible additional capital investment for nuclear power plant for differential of 0·1 pence per shaft horse-power hour between the direct fuel cost from nuclear and conventional oil-fired power plant.

TABLE II.—*Power Requirements for Large Oil Tankers*

Deadweight	s.h.p.
Tons	
32,000	12,500
47,000	16,000
65,000	22,000
80,000	30,000
100,000	40,000

reactors are unlikely to be strong competitors for installations smaller than 20,000 s.h.p.

The other British paper, P265,[8] by S. L. Smith and J. E. Richards of the British Shipbuilding Research Association, gives some sobering figures which are well known to the shipping industry, but which have tended to be ignored by nuclear engineers. The power requirements of even large tankers are quite small by nuclear standards, as may be gathered from Table II above.

For instance, Moore and Iliffes' restriction to powers greater than 20,000 s.h.p. is equivalent to saying that in the immediate future we can be interested only in ships larger than 65,000 tons dwt. Fortunately for the nuclear industry, the growth of large tankers is so rapid that even this restriction may still leave a worthwhile market. For instance, one year ago nearly 400 tankers over 40,000 tons dwt. were building or contracted. But Smith and Richards also point out that even for such large ships it will be necessary to build the reactor for what on present prices is a very low figure. The cost of a 65,000 ton nuclear ship must certainly not exceed the normal capital cost of a conventional ship by more than £2 million, and it is very probable that a lower figure, around £1 million, may have to be achieved. The extent to which capital investment in a nuclear ship may exceed that in a conventional vessel is shown graphically in Fig. 5. The permissible capital cost is critically dependent on the fuel cost, and the availability of cheap enriched fuel may turn out to be the crucial factor. The authors conclude that the immediate prospects for commercial nuclear propulsion do not appear to be very bright, though they have hopes that eventually it will become suitable for the propulsion of certain types of large merchant ships.

Comment on Ship Reactors

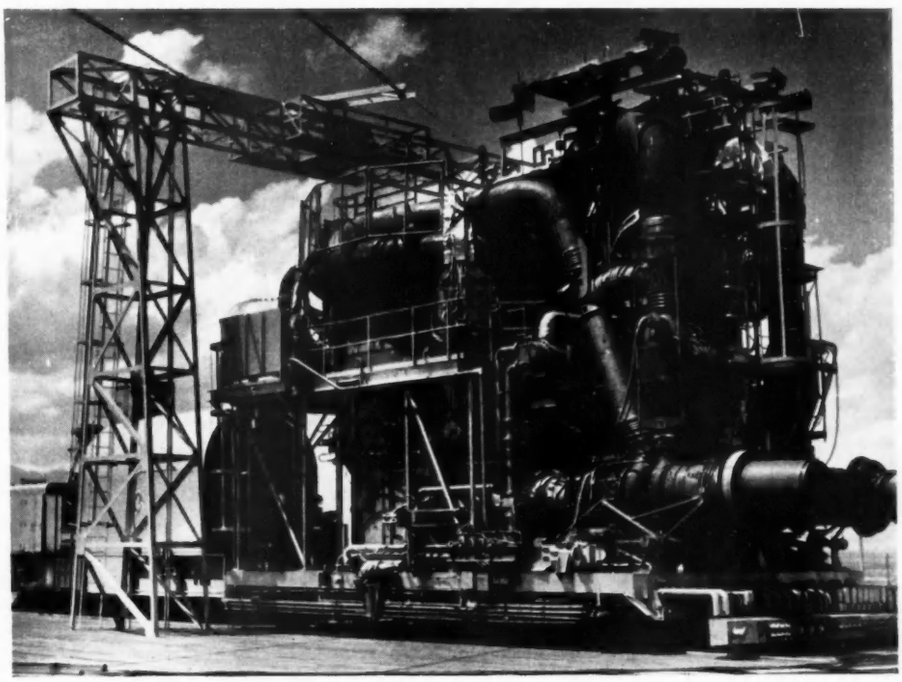
The papers on marine propulsion must have been written some months prior to Geneva. It is therefore understandable that most of them do not discuss—in the detail which would now seem appropriate—the recent very promising developments in the field of boiling and organic-moderated reactors. Marine engineering needs stable and safe reactors, capable of being built in fairly small sizes (approximately 15 to 20 MW (electrical)) at low capital cost. The work on land-based power reactors reported at Geneva (in papers P421,[9] 606[10] 1923,[11] 2372[12] and 2379[13]) made it clear that the boiling and organic reactors are as promising as any which have yet been proposed for ship propulsion. One American declassified report (TID 7539)[14] which was available at Geneva, provides some figures which add weight to this view. A boiling reactor design for a 22,000 s.h.p., 38,000 dwt. ton tanker is discussed. Capital costs would be 45 per cent higher than conventional costs (compared with 100 per cent for the Savannah). Evidently the gap is gradually being closed.

Aircraft

There was one paper which read a little strangely in the context of Atoms for Peace. This was P465,[15] by D. R. Shoults, and it dealt with some of the American work on nuclear aircraft carried out in 1956. The paper gives a general description of Heat Transfer Reactor Experiment No. 1, in which an air-cooled, water-moderated reactor, fuelled with metal plates, was used to drive a direct-cycle gas turbine. The engine was started up on chemical fuel and switched over gradually to nuclear power. No difficulty was experienced during this operation. The design life of the reactor was 100 hours, and a 90 hour run was obtained. Details of operation and methods of maintenance are tantalisingly sparse, though sufficient to remind us that nuclear aircraft propulsion is a pursuit for those with money to burn. Fig. 6 shows a nuclear reactor (centre) at the National Reactor Testing Station, Idaho, used to power two aircraft turbojet engines (right). Before operation the reactor is pushed on tracks to a deserted area by a locomotive.

At one of the Press conferences which were such a useful feature of Geneva H. L. Reynolds (United States, the author of P2408[16]) made a brief reference to American work on nuclear rockets and ramjets. He said that Los Alamos has a project known as Rover, and that the Livermore laboratory is conducting the Pluto ramjet project, and will be holding tests in Nevada " very shortly."

Fig. 6 (below). Test reactor coupled to two aircraft jet engines (USA).



Atomic Review

Under Cover

LEGISLATION on the licensing and insurance of nuclear installations—liability up to a maximum of £5 million to be provided by insurance cover. Plant for reactors and research.

Licensing and Insurance of Reactors

The intention of the Nuclear Installations (Licensing and Insurance) Bill, which has recently been published, is to ensure that nuclear reactors on land are made effectively subject to control in the interests of safety and that their owners make adequate provision for the payment of compensation should the need arise. The construction and operation of a nuclear reactor will require a licence from the Minister of Power (in Scotland the Secretary of State) who may impose such conditions as he thinks necessary for safety. He will have the power to recruit an expert staff to assist him in determining the conditions and in seeing that they are carried out. The maximum liability in respect of one incident is £5 million.

Every licensee will be under a duty to prevent damage to property or personal injury from radioactive contamination and will, therefore, be liable to pay compensation for such damage even if it is due to an unavoidable accident, except to the extent that the claimant has been guilty of contributory negligence. The licensee will be required to insure his liability or show that he is holding adequate liquid assets. The liability is, however, to be limited in effect to £5 million in respect of any one incident. It is not believed that there is any real danger of damage up to anything like this figure. For example, the cost of the damage following the Windscale accident was less than £100,000. In the highly unlikely event of an incident causing more than £5 million worth of damage, special measures would be needed. Therefore if the Minister considers that the claims arising from any one incident are likely to exceed £5 million, he will have to certify accordingly and thereupon no claims will be dealt with until Parliament so determines.

Since certain types of injury from radiation may not become manifest for a long time the Bill provides that actions for damages may be instituted up to ten years after the time when the radiations giving rise to the injury were emitted. (The normal period of limitation for actions concerned with personal injury is three years, and for actions concerned with damage to property six years in England and Wales and 20 years in Scotland.)

The liability of the United Kingdom Atomic

Continued on next page

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Continuing Atomic Review

Energy Authority is already similar to that proposed for licensees under the Bill but is not limited in amount. The Bill contains provision to extend the Authority's present liability to cover nuclear fuel in the course of carriage and to apply the ten year period of limitation to actions against them. Any Government department constructing a reactor will be in a similar position to the Authority. The licensing provisions of the Bill do not extend to the Authority, whose operations are of a special character, or to Government departments, since it is not the normal practice to require one Government department to obtain a licence from another.

The Bill applies to nuclear reactors of the fission type but its provisions can be extended by regulation to other plant connected with atomic energy. It applies only to installations on land; reactors in ships, submarines and aircraft present special problems which need further study having regard particularly to their international aspects. The insurance market have informed the Government that they are ready to provide the necessary cover. Questions about premiums are a matter for the insurance market and the reactor owners. The Government's intention to introduce legislation on these lines was announced in the House of Commons on 10 February, 1958, by the Parliamentary Secretary to the Minister of Power. The legislation is to extend to Northern Ireland where the responsible Minister will be the Minister of Commerce for Northern Ireland. It may also be extended by Order in Council to the Channel Islands and the Isle of Man.

Plant and Equipment

Gas Bearing Circulator

A gas bearing circulator, class NFB, is being produced by Ruston and Hornsby Limited, Lincoln. The unit has been developed by the company's nuclear division and is suitable for engineering laboratory experiments and for the auxiliary circuits of large gas-cooled reactors. It will be used by Ruston's own research centre to further the work on the design and development of nuclear power stations of 5–25 MW output. The circulator is shown in Fig. 1 and its rotating assembly in Fig. 2.

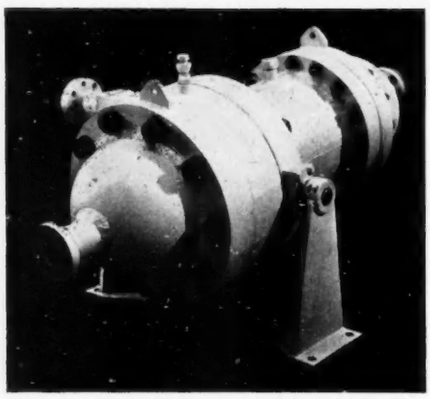


Fig. 1 All moving parts in the gas circulator are contained within a sealed pressure vessel.

The unit is intended for use where it is desirable to circulate gas at high temperature and pressure without leakage. Oil bearings are avoided by carrying the rotating assembly of the circulator on bearings which use the pumped gas—air, carbon dioxide, or helium—as a bearing fluid. The production of such bearings calls for exceptionally high standards of machining, the shaft diameter being correct to within 50 micro-inches over a 5½ in length. The NFB unit shown in the illustration has an overall length of 4 ft 9 in and a height of 2 ft 3 in. Pressures up to 450 lb per sq. in absolute, and temperatures up to 450° C can be accommodated. When driven by a variable frequency supply, the circulator will operate over a speed range of 10 : 1. All moving parts are contained within a sealed pressure vessel, the electrical leads being brought out through " vacuum tight " seals.

Diffusion Pump for Large Vacuum Systems

Metropolitan-Vickers Electrical Company Limited has recently introduced a new diffusion pump—the " Metrovac " type 9/14, shown in Fig. 3. This pump has been designed primarily to give its highest pumping speeds at the lower pressures; it is thus very suitable for the large vacuum systems used in nuclear physics research, and did in fact form the basis of the high vacuum system supplied by Metropolitan-Vickers for the evacuation of the ZETA torus. Both oil and mercury versions of the pump are available. The characteristics of the pump are those of a 14 in diameter pump at pressures below 5×10^{-4} mm Hg, and of a 9 in diameter pump at higher pressures (of the order of 10^{-3} mm Hg), but with a power consumption of only 2·5 kW for the oil pump and 3 kW for the mercury pump.

The peak unbaffled air speed of the oil pump is 2,850 litres per second, which is a far higher speed than that attained by conventional pumps with the same power consumption.

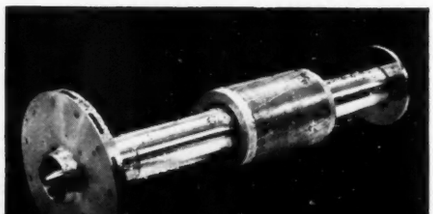


Fig. 2 The circulator rotating assembly.

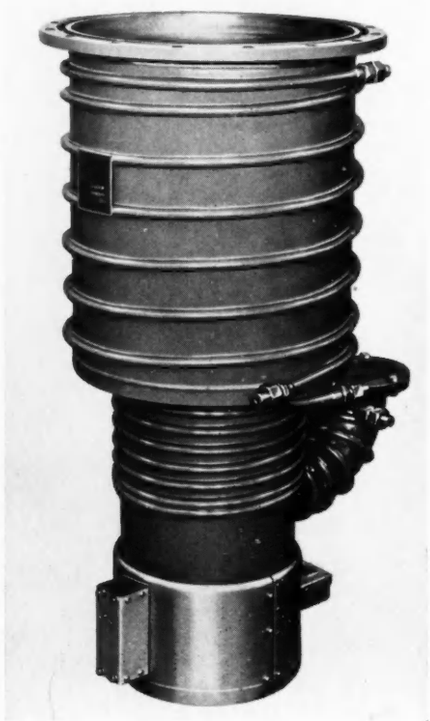


Fig. 3 Metropolitan Vickers Metrovac type 9/14 diffusion pump as used in the vacuum system of ZETA.

Notes and News

USAEC Chairman in Britain

Mr. John A. McCone, chairman of the United States Atomic Energy Commission, and Dr. Willard F. Libby, member of the Atomic Energy Commission, are to visit various atomic energy establishments in Great Britain during November. They will also have discussions with Sir Edwin Plowden, the chairman, and other members of the UK Atomic Energy Authority. Mr. McCone and Dr. Libby arrived in this country on 2 November.

Canadian Delegation in Britain

Mr. Lorne Gray, chairman of Atomic Energy of Canada Limited, led a party of Canadians on a visit of United Kingdom nuclear installations which started on 10 October, 1958. Besides Mr. Gray, the party consisted of: Mr. J. S. Duncan, chairman Ontario Hydro; Mr. R. L. Hearn, director, AECL, and consultant to Ontario Hydro; Mr. H. A. Smith, deputy general manager, Ontario Hydro and manager of the Nuclear Power Plant Division, AECL; and Mr. J. S. Foster, deputy general manager of the Nuclear Power Plant Division, AECL.

Exploiting Patents

Mr. J. A. Gay has been appointed patents exploitation officer to the United Kingdom Atomic Energy Authority in succession to Mr. T. Benson Gyles. Inventions developed in the course of atomic energy work which are available for commercial exploitation continue to be filed at the rate of about eight a month. Many of them may be applied in a wide variety of industries, both inside and outside atomic energy, and the total number of inventions available for use by firms is now well over 400. Applications for details of such inventions should be made to Mr. Gay at the United Kingdom Atomic Energy Authority, 11 Charles II Street, London, S.W.1.

Research Manager for Parsons Centre

C. A. Parsons and Company Limited announce that the United Kingdom Atomic Energy Authority have agreed to release Dr. H. M. Finniston, at present Head of the Metallurgy Division at the Research Establishment at Harwell, to become research manager of their Nuclear Research Centre in Newcastle. All nuclear and other research work relating to the reactor is the responsibility of Parsons within the organisation of the Nuclear Power Plant Company Limited, of which they are a member company.

Cerenkov Effect

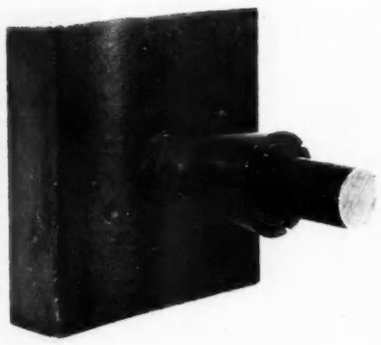
The award of the Nobel Prize in Physics jointly to the Soviet scientists Academician I. Y. Tamm, Professor I. M. Frank and Dr. P. A. Cerenkov, has drawn attention to the effect that bears the latter's name. It has also prompted a claim from the French physicist, Professor Lucien Mollet, that the luminescence of liquids under the effect of gamma rays was discovered by him in 1926, eight years before the Russian discovery of the same phenomenon.

The Cerenkov effect, known in the Soviet Union as the Vavilov-Cerenkov effect (since its discovery was the result of experiments suggested by Academician S. I. Vavilov, formerly President of the Soviet Academy of Sciences, whereby liquids were irradiated by gamma rays from radium) is more familiar as the blue glow seen in the neighbourhood of the fuel elements in water-moderated reactors. In 1937 Academician Tamm and Professor Frank developed a theory to explain the phenomenon based on classical electrodynamics. Cerenkov effect is defined as the emission of a (usually) bluish light by electrons or other electrically charged particles that move at a velocity commensurate with that of light.

A charged particle of high energy in passing through a dielectric produces local polarisation along its path. Immediately afterwards the polarised molecules return to their quiescent states with emission of light. When the particle velocity is less than that of light in the medium, the light pulses from individual molecules are damped out owing to destructive interference. At velocities greater than that of light, interference is constructive and the light pulses reinforce each other. The compound pulse is known as Cerenkov radiation.

Construction

WEDGE ANCHOR FOR PRESTRESSING SYSTEM



The Macalloy wedge grip anchor and end plate with tapered hole for use with the Lee-McCall prestressing system.

A new design of anchor grip has been developed by McCalls Macalloy Limited, Templeborough, Sheffield, for use with the Lee-McCall prestressing system. As shown in the accompanying illustration, the bar to be tensioned is gripped by a three-piece conical wedge fitting the tapered hole of the end plate. The end plate has also two small $\frac{7}{16}$ in diameter holes for fixing the plate to the formwork and for holding the grouting flanges if they are used.

This type of grip is an additional method to the threaded anchorage which is also used with Macalloy bars and has the advantage that the wedge can be anchored anywhere along the bar, whereas the threaded end is limited to units of predetermined lengths. With wedge type grips, stock lengths of bar can be used for any size of concrete member, and length tolerances in the manufacture of concrete members need not be exacting. There is the additional advantage that the tensioned member presents a nearly flush end. A higher initial jacking stress of 45 tons per sq. in is also recommended for these bars with the wedge grip, as compared with 42 tons per sq. in with a threaded anchorage.

HEATING AND VENTILATING DEEP UNDERGROUND SPACES

Deep underground tunnels provide special heating and ventilation problems. A better understanding of heat flow in these locations would be of considerable value to the designers of ventilation systems for deep mines, subterranean road and railway systems, and underground factories. The report of an investigation undertaken by the Building Research Station of the Department of Scientific and Industrial Research and recently published—" Heat transfer in deep underground tunnels," by A. W. Pratt and L. F. Daws (National Building Studies, Research Paper No. 26, HMSO London, 1958)—suggests a theoretical treatment of this problem which had been checked by large-scale experiments in a tunnel in chalk cliffs on the south coast.

The experiment was carried out over a continuous period of about two years in a sealed section of the tunnel in which had been installed temperature measuring, heating and ventilating equipment. The experiment was in five phases, each representing different conditions of heat input as follows: (1) heat input at a constant rate of 2 kW for a continuous period of seven weeks with no ventilation, (2) heat input increased to 4·8 kW and maintained constant for eleven weeks with no ventilation, (3) cycle heating with heat input of 4·8 kW for 12 hours, then heating off for 12 hours, with no ventilation, (4) phase 1 repeated, (5) heat input at a constant rate of 5·5 kW with ventilation at a rate of about seven air changes per hour.

Details of the experimental method, including the scheme of instrumentation, and the fitted values for the thermal conductivity and diffusivity at the surface and depths up to 8 ft in the damp chalk walls based on the experimental measurements and appropriate theoretical solution, are given in Part 1 of the Research Paper. Part 2 contains the mathematical treatment and Part 3 considers the results of the experiment and of the theoretical analysis together.

It is concluded from this investigation that temperature conditions in a deep underground tunnel, heated and ventilated in a specified manner, may be calculated provided the thermal properties of the material surrounding the tunnel are known. In this way it is possible to relate the rate at which the temperature in the tunnel rises with time, to the rates of heating and ventilating, to the occupancy, and to the thermal properties of the material surrounding the tunnel. In the case of a tunnel in chalk containing about 30 per cent by weight of water, it has been shown that for heating rates varying from 4 to 12 B.t.u. per hour per sq. ft, the conductivity of the material is some two to three times the corresponding value for the dry material. The thermal diffusivity of the damp material is probably greater than that of the dry material.

NEW LINES IN SPACE HEATING

A pleasing design of space heating equipment is now being manufactured by Copperad Limited, Colnbrook. Marketed under the trade name " Sill-Line " it is, as the name suggests, designed for installation beneath window sills.

As shown in Fig. 1, it is particularly suited for the provision of long continuous heating runs in large office blocks and similarly constructed modern buildings where construction is based on a uniform module arrangement. Furthermore, this system of heating, unlike radiators and convectors, allows more flexibility in the use of room space to suit staff requirements, since it allows partitions to be erected or rearranged without adversely affecting the uniform heating of rooms or offices. As an added refinement, individual damper control can also be fitted when required.

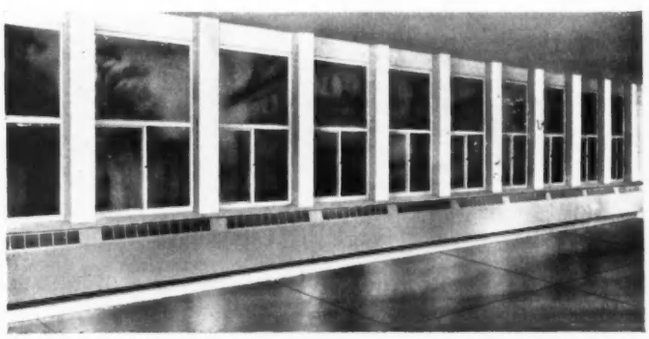
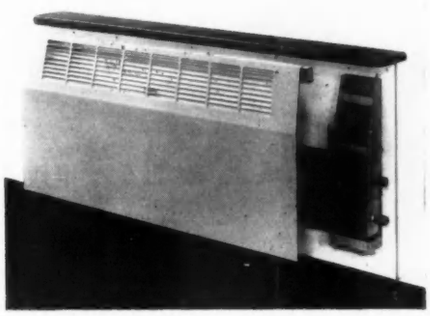


Fig. 1 A Sill-Line space heating installation provides uniform heating independent of the location of office partitions.

Fig. 2 Simple construction of Sill-Line space heaters with no exposed pipework or screw heads. Installation is easy and economical.



The equipment shown in Fig. 2 is made in high grade sheet steel and a feature of the design is the use of clips and spring fittings so that no screw heads are visible. All pipework and convector surfaces are enclosed and no floor space is occupied. A backing of ½ in builders board is usually provided on the brick or concrete internal facing. The unit is easy and economical to instal, and the heat source can be steam or hot water supplied from boilers using solid fuel, oil or gas.

Sill-Line equipment, to a total length of 13,000 ft, is being installed in State House, High Holborn, London, a 17-storey office block with a quarter of a million square feet of office space. In this case the heat will be supplied by Davey Paxman medium pressure hot-water " Ultranomic " boilers.

Design

HOW TO CROSS AN UNSAFE BRIDGE

A Diversion in Dynamic Plasticity

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of
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The problem of crossing a bridge with a vehicle whose mass exceeds that which placed centrally on the bridge would cause collapse is examined in this article. It is shown that irrespective of the speed of the vehicle, the span of the bridge, or whether it be simply supported or encastré, the overload should not exceed 22·77 per cent. For overloads up to 20 per cent and spans up to 100 ft, the speeds needed to limit the final deformation of the bridge to a reasonable value are shown to be within the compass of most modern vehicles.

The dynamic response of a bridge to a load moving across it has been considered by many authors, and at least one (the late Professor Sir Charles Inglis, 1934) has made it the subject of a major treatise. Nearly all of this work, however, has been confined to the elastic behaviour of the bridge, it being assumed that if the stress anywhere approached the yield value that the design was unsatisfactory. Recent work on the quasi-static loading of structures (e.g., Baker, J. F., *et al.*, 1956) has suggested that this criterion is not a satisfactory one, and it is natural to enquire whether a more rational approach is not possible to the dynamic problem also.

The general dynamic elasto-plastic problem is a particularly difficult one and useful results have only been obtained in certain very simple cases (Duwez, P. E., *et al.*, 1950, and Thomson, W. T., 1954) but, by ignoring the elastic deformation of the bridge entirely and regarding the moment-curvature relation as rigid-plastic, more complicated problems can be solved, although it is necessary, of course, to put restrictions on the application of the solutions to practical materials (Lee, E. H., and Symonds, P. S. ,1952; Conroy, M. F., 1952 and 1955; Symonds, P. S., 1953; Symonds, P. S., and Leth, C. F. A., 1954; Seiler, J. A., and Symonds, P. S., 1954; Parkes, E. W., 1955, 1956 and 1958; Hopkins, H. G., 1955).

The present article applies the rigid-plastic method to the following problem: given a bridge of uniform section which will collapse under a mass M_s stationary at its centre, how does one get across with a vehicle of mass αM_s where α is greater than unity? Analysis and commonsense suggest that the answer is "fast!" The problem answered here is how fast and whether there is any absolute limitation on α.

The solution is offered not as a practical aid to bridge building but as something a little more than a *divertissement* for plasticians. It represents one extreme solution of the dynamic problem just as the all-elastic approach represents another. The true answer to the problem of a bridge under a moving load lies somewhere between the two.

Notation

A, B	arbitrary constants.
F	tractive force of vehicle.
M	mass of vehicle.
M_p	plastic moment of bridge section.
M_s	mass which placed centrally on bridge would cause collapse
Rl (r)	Spence's integral of the second kind
g	acceleration due to gravity
l	span of bridge
r	co-ordinate defining position of vehicle
r_1	position at which deformation begins
r_2	position at which deformation ends
t	time
v	speed of vehicle
y	final deflection at any point
α	M/M_s
λ	co-ordinate defining position along bridge
θ	slope at far support

ANALYSIS

Consider a vehicle of mass M moving across a bridge of span l having a uniform section of plastic moment M_p. The mass of the bridge will be assumed to be negligible compared with M, so that the analysis is confined to short spans, and M_p will be taken as constant (i.e., independent of the rate of strain). Then the maximum value of M which can be sustained at the centre of the span is given by

$$M_s = \frac{4\,M_p}{g\,l} \text{ (simply supported ends)} \quad (1a)$$

or

$$M_s = \frac{8\,M_p}{g\,l} \text{ (encastré ends)} \quad . \quad . \quad (1b)$$

Suppose that M is equal to αM_s, where α is a factor greater than unity. Then when the vehicle is on the centre part of the bridge some permanent deformation of the structure will take place. Let the vehicle be moving from left to right and let conditions at time t and time $t + \delta t$ after deformation begins be as shown in Fig. 1. It has been found previously (Parkes, 1956) that the dynamic plastic deformation of a beam whose mass is negligible compared with that of the applied load consists of hinge rotations at the supports and under the load only. It follows that that part of the bridge which the vehicle has not yet crossed has remained straight and the position of the vehicle can be defined by the length of this portion, r, and the angle at the far support, θ. It is assumed that due to the engine or brakes of the vehicle a variable tractive force F is applied to it.

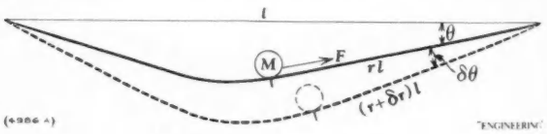

Fig. 1 Displacements at time t and time $t + \delta t$, the vehicle moving from left to right.

In time δt the angle at the right-hand support increases by $\delta\theta$ and that at the left-hand support by $r\,\delta\theta/(1 - r)$; the angle of the plastic hinge under the vehicle changes by the sum of these. It follows that the work done in plastic hinge(s) in time δt is given by

$$\frac{\delta\theta\,M_p}{1-r} \text{ (simply supported ends)} \quad . \quad (2a)$$

or

$$\frac{2\,\delta\theta\,M_p}{1-r} \text{ (encastré ends)} \quad . \quad . \quad (2b)$$

The loss of potential energy of the vehicle in time δt is

$$M g\,l\,(r\,\delta\theta + \theta\,\delta r) \quad . \quad . \quad (3)$$

and its gain of kinetic energy is

$$M\,l^2\,(\dot{r}\,\ddot{r} + r\,\dot{r}\,\dot{\theta}^2 + r^2\,\dot{\theta}\,\ddot{\theta})\,\delta t \quad . \quad (4)$$

(rotational inertia of the vehicle is ignored). The work done by the force F is equal to

$$-\,F\,l\,\delta r \quad . \quad . \quad . \quad (5)$$

For conservation of energy of the whole system during the interval δt

$$M g\,l\,(r\,\dot{\theta} + \theta\,\dot{r}) - F\,l\,\dot{r} = \frac{\dot{\theta}\,M_p}{1-r} + M\,l^2\,(\dot{r}\,\ddot{r} + r\,\dot{r}\,\dot{\theta}^2 + r^2\,\dot{\theta}\,\ddot{\theta}) \quad . \quad (6a)$$

or

$$M g\,l\,(r\,\dot{\theta} + \theta\,\dot{r}) - F\,l\,\dot{r} = \frac{2\,\dot{\theta}\,M_p}{1-r} + M\,l^2\,(\dot{r}\,\ddot{r} + r\,\dot{r}\,\dot{\theta}^2 + r^2\,\dot{\theta}\,\ddot{\theta}) \quad . \quad (6b)$$

Resolving along the bridge,

$$M g\,\theta - F = M\,l\,(\ddot{r} - r\,\dot{\theta}^2) \quad . \quad (7)$$

Eliminating F between equations (6) and (7) and putting $M = \alpha M_s$, where M_s is given by equation (1), it is found that

$$\frac{l}{g}\frac{d}{dt}(r^2\,\dot{\theta}) = r - \frac{1}{4\,\alpha\,(1-r)} \quad . \quad (8)$$

This equation is applicable to beams with simply supported or encastré ends. It can be interpreted physically as follows. The right-hand side represents the difference between the weight of the vehicle tending to cause deformation and the resistance to motion of the plastic hinges formed in the bridge; it is positive when the vehicle is on the centre part of the bridge, and when the vehicle is near the ends it is negative. The left-hand side represents the rate of change with time of the angular momentum of the vehicle about the far hinge.

To solve equation (8) some relation must be postulated between r (position on the bridge) and t (time). The simplest is to assume that the vehicle is driven at constant speed v, so that $\dot{r}$ is

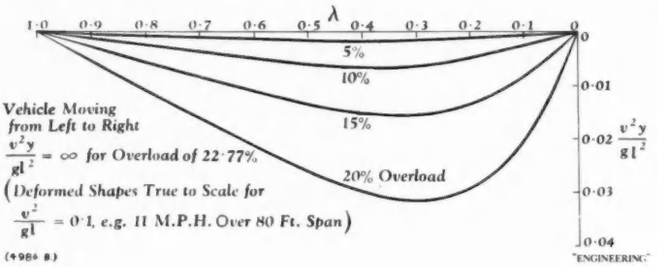

Fig. 2 Final deformed shape of bridge, after the vehicle has crossed right over.

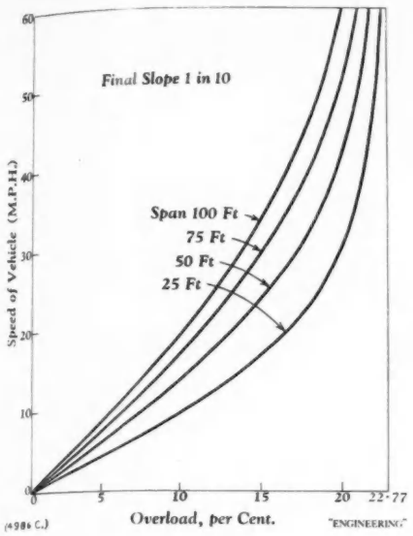

Fig. 3 Final slope, 1 in 10.

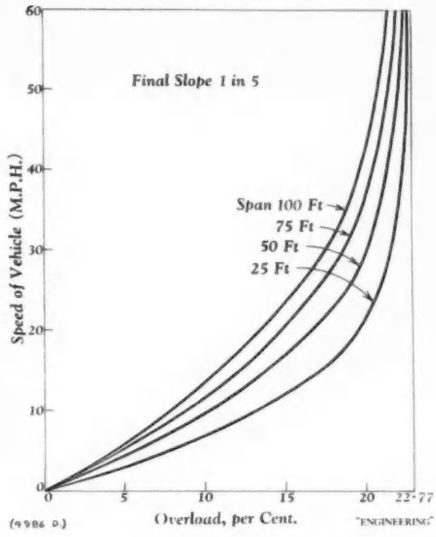

Fig. 4 Final slope, 1 in 5.

Figs. 3 and 4 Vehicle speeds necessary to cross a bridge of given span when the final slopes are as indicated.

equal to $-\frac{v}{l}$. Equation (8) can then be integrated as

$$-\frac{v^2}{g}r^2\dot{\theta} = \frac{r^2}{2} + \frac{\ln(1-r)}{4\alpha} + A$$

where A is an arbitrary constant, which can be re-phrased in the form

$$\frac{d}{dr}\left(\frac{v^2\theta}{gl}\right) = \tfrac{1}{2} + \frac{\ln(1-r)}{4\alpha r^2} + \frac{A}{r^2}. \quad (9)$$

Integrating equation (9) we have

$$\frac{v^2\theta}{gl} = \frac{r}{2} + \frac{1}{4\alpha}\left\{\ln(1-r) - \ln r - \frac{\ln(1-r)}{r}\right\} - \frac{A}{r} + B \quad . \quad . \quad . \quad (10)$$

where B is another arbitrary constant.

To determine A and B the initial conditions must be considered. Motion will start when the bending moment under the vehicle first reaches M_p. This happens at a value of r (r_1) given by the larger root of the equation

$$4\alpha r_1(1-r_1) = 1 \quad . \quad . \quad (11)$$

(It may be noted that this is equivalent to making the right-hand side of equation (8) zero.) Substituting $d\theta/dr = 0$ when $r = r_1$ in equation (9) we find

$$A = -\frac{r_1^2}{2} - \frac{1}{4\alpha}\ln(1-r_1). \quad (12)$$

Putting $\theta = 0$ when $r = r_1$ in equation (10) and substituting for A we have

$$B = -r_1 - \frac{1}{4\alpha}\ln\left(\frac{1-r_1}{r_1}\right). \quad (13)$$

Substituting equations (12) and (13) in (9) and (10) we obtain

$$\frac{d}{dr}\left(\frac{v^2\theta}{gl}\right) = \tfrac{1}{2}\left(1 - \frac{r_1^2}{r^2}\right) + \frac{1}{4\alpha r^2}\ln\left(\frac{1-r}{1-r_1}\right) \quad . \quad . \quad . \quad (14)$$

and

$$\frac{v^2\theta}{gl} = \frac{r}{2}\left(1 + \frac{r_1^2}{r^2}\right) - \frac{1}{4\alpha r}\ln\left(\frac{1-r}{1-r_1}\right) - r_1 + \frac{1}{4\alpha}\ln\left(\frac{1-r}{r}\,\frac{r_1}{1-r_1}\right). \quad (15)$$

Deformation of the bridge begins when $r = r_1$; it ceases when $\frac{d\theta}{dr}$ is again zero. Denoting the value of r when displacement ceases by r_2, it is found from equation (14) that

$$\tfrac{1}{2}\left(1 - \frac{r_1^2}{r_2^2}\right) + \frac{1}{4\alpha r_2^2}\ln\left(\frac{1-r_2}{1-r_1}\right) = 0. \quad (16)$$

Some values of r_1 and r_2 for different factors α, computed from equations (11) and (16), are given in Table I. It will be noted that for values of α greater than 1·2277, deformation has not ceased before the vehicle has reached the far end of the bridge. But if equation (15) is still applicable when r is zero, θ becomes very large. It follows that a vehicle of mass greater than 1·2277 M_s cannot cross the bridge.

For vehicles of mass less than 1·2277 M_s the amount of permanent deformation of the bridge which ensues can be found as follows. The final displacement, y, of any point $r = \lambda$ in the bridge between $r = r_1$ and $r = r_2$ is given by

$$y = \lambda\theta l + \int_{r=\lambda}^{r=r_2}\frac{(1-\lambda)}{(1-r)}\,r\,l\,d\theta \quad (17)$$

where the first term represents the displacement when the vehicle is at λ, and the second term is the displacement added subsequently. By substituting for θ and $d\theta$ from equations (15) and (14) and evaluating the integral, the final displacement can be obtained from equation (17) in the non-dimensional form

$$\frac{v^2 y}{g l^2} = \frac{(r_1-\lambda)^2}{2} + \frac{1}{4\alpha}\left\{\lambda\ln\frac{r_1}{\lambda} - (1-\lambda)\ln\left(\frac{1-\lambda}{1-r_1}\right)\right\} + (1-\lambda)\left[\frac{r_1^2}{2}\ln\left(\frac{1-r}{r}\right) - \tfrac{1}{2}\{r + \ln(1-r)\} + \frac{1}{4\alpha}\left\{\ln(1-r_1)\ln\left(\frac{1-r}{r}\right) - \frac{\ln^2(1-r)}{2} + \ln(1-r)\ln r - \mathrm{Rl}(r)\right\}\right]_{\lambda}^{r_2} \quad (18)$$

where

$$\mathrm{Rl}(r) = \int\frac{\ln r}{r-1}\,dr \quad . \quad . \quad (19)$$

Rl (r) is known as Spence's (1809) integral of the second kind. It is tabulated to seven decimal places for $r = 0\,(0{\cdot}01)\,2\,(0{\cdot}02)\,6$ by Powell (1943). For points between $r = 1$ and r_1, and between $r = r_2$ and 0, the bridge remains straight.

NUMERICAL RESULTS

The permanent deflections of the bridge, calculated from equation (18) are plotted in Fig. 2 for $\alpha = 1{\cdot}05$, $1{\cdot}10$, $1{\cdot}15$ and $1{\cdot}20$. It will be noted, as might be expected, that as the percentage overload increases, the point of maximum deflection moves nearer the far hinge. For this reason maximum deflection is not a very satisfactory criterion of deformation—instead, the final slope which the vehicle has to climb will be used. This is given by $y_{(\lambda=r_2)}/r_2 l$. It is tabulated (in non-dimensional form) for various α in Table II.

From Table II it is possible to calculate the speed with which a vehicle having a certain overload must cross a bridge of given span in order to limit the final slope to a given value. In Figs. 3 and 4 this speed (in m.p.h.) is plotted for spans of 25, 50, 75 and 100 ft, and for final slopes of 1 in 10 and 1 in 5. It will be noted that overloads up to 20 per cent can be carried over spans up to 100 ft at speeds within the compass of most modern vehicles.

TABLE I.—*Changes in r_1 and r_2 for values of α*

α	r_1	r_2
1·00	0·5	0·5
1·05	0·6091	0·2641
1·10	0·6508	0·1647
1·15	0·6806	0·0903
1·20	0·7041	0·0292
1·2277	0·7153	0

TABLE II.—*Final Slope for Various Values of α*

α	Final slope $\times \frac{v^2}{gl}$
1·00	0
1·05	0·0046
1·10	0·0244
1·15	0·0763
1·20	0·2335
1·2277	∞

VALIDITY FOR STEEL BRIDGES

The analysis given above has been developed for a bridge having a rigid-plastic moment-curvature relationship and a dynamic plastic moment independent of the rate of strain. Mild steel is an elasto-plastic material showing strain-rate sensitivity. The validity of the results when applied to mild steel bridges will depend on whether the possible elastic deformations of the bridge are small compared with those in the plastic range and on whether the dynamic plastic moment can be regarded as constant. Evidence by Parkes (1958) suggests that the latter may be sufficiently true, although the dynamic value may have to be taken as different from the " static " M_p.

The end slope of a centrally loaded and simply supported mild steel bridge just before collapse is about 1 in 70 for a bridge of 20 : 1 span to depth ratio and 1 in 140 for a bridge of 10 : 1 span to depth ratio. For an encastré bridge the maximum slopes are less than these. The elastic deformations are therefore small compared with those achieved plastically.

The results would thus seem to be generally applicable to steel bridges, but it should be remembered that lack of accurate knowledge of material properties is likely to be significant in a problem where one is hoping, at best, to carry an overload of the order of 20 per cent.

CONCLUSIONS

An analysis has been given for the permanent deformation of a light rigid-plastic bridge crossed by a vehicle of mass αM_s, where M_s is that mass which placed centrally on the bridge would just cause collapse, and α is a factor greater than unity. It is found that the mode of deformation is the same whether the bridge be simply supported or encastré and that irrespective of the speed of the vehicle and the span of the bridge,

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Continuing **Design**

NOISE

Symposium Held at the Institution of Mechanical Engineers

A Symposium on Engine Noise and Noise Suppression was held recently by the Institution of Mechanical Engineers. Four papers were presented for discussion: "Noise and Hearing: Physiological Aspects," by Professor W. Burns of Charing Cross Hospital: "Reduction of Internal-Combustion Engine Noise by Enclosure," by Dr. A. J. King, Metropolitan-Vickers Electrical Company Limited: "Origins of Diesel Engine Noise," by Dr. A. E. W. Austen and Dr. T. Priede, C.A.V. Limited; and "Measurement of the Noise of Motor Vehicles," by Dr. W. Martin, Silencer Construction Department, Eberspächer, Germany. We give below a summary of the main points in the written papers.

OCCUPATIONAL EFFECTS

The result of continued daily exposure of the ear to loud noise of the types commonly encountered in industry, over a period of years, is not dramatic. Small losses of sensitivity usually occur first at high frequencies, especially in the region of 4,000 c/s; initially, such losses are subjectively quite undetectable, but they increase progressively. If the noise is intense these changes may progress significantly and a spread occurs to lower frequencies. When this appreciably involves frequencies between 300 and 3,000 c/s, the understanding of conversation becomes impaired and some degree of social handicap is felt.

In very intense noise, such discomfort may be caused that ear protection is essential, and is consistently worn, so that aural damage may virtually be eliminated, provided really efficient ear protection is used. In the most intense noise, of the order of 150 dB, non-auditory effects become serious; pain in the face, disorientation, nausea, and vomiting may incapacitate those exposed, and such experiences should be avoided.

Impact noise, such as that from riveting, hammering, press-tools, and the like, is difficult to assess from the standpoint of aural damage. It is generally believed to be particularly harmful to the hearing mechanism.

The ear can be protected by either external or internal devices. Internal plugs are cheap, light, and effective over a wide frequency range. The degree of protection is greatest at the higher frequencies and least at low frequencies. The external type of protector or ear muff is a cup of roughly hemispherical form enclosing the whole ear, which is more comfortable to wear than the internal type, and in its latest form, as developed by the National Research Council of Canada, is extremely efficient acoustically.

If the noise level in a working environment, with or without reduction at source is hazardous, a hearing conservation programme must be put into effect, and this must be the final responsibility of the industrial medical officer. Where necessary, ear protection must be worn and here lies perhaps the most difficult aspect. It is not easy to convince people that ear protection is worth the trouble. Periodical re-examination of the hearing, at intervals of months, or yearly, depending on circumstances, should be a part of any hearing conservation programme.

ENCLOSURE VIBRATIONS FROM MOUNTING

The noise radiated by an internal combustion engine is made up of "primary" and "secondary" noise—primary noise being that radiated directly to the surrounding air by the engine itself. Secondary noise is radiated by vibrating surfaces—surrounding walls, ceilings and floors—set in vibration by conduction through the engine mounting and building structure. It is secondary noise that has been responsible for many unsuccessful acoustic enclosures.

The remedy is to mount the engine on resilient mounts which yield readily to engine vibrations. If the engine is mounted on a large concrete block, an air gap should be left round the block, and the acoustic enclosure should rest on the surrounding ground, not on the block. The concrete block can be resiliently supported, preferably from the top so that the centre of gravity of the combined engine and block is approximately in the plane of the supports. This avoids coupling the vertical and rocking modes of vibration, and improves stability. All connections between the engine and the enclosures, such as pipes and cables, must be at least as flexible as the supports.

NOISE FROM DIESELS

Long-term studies of the airborne noise emitted by a diesel engine resiliently mounted on a test bed have shown that air intake noise, and valve and timing covers are liable to be strong sources of noise. Reduction in the noise from them may produce a major quietening, and mechanical noise or injection-equipment noise may then be prominent. In some engines, smoothing the cylinder pressure may help.

All of the remaining sources are believed to involve resonant vibrations of the crankshaft-flywheel system, the crankshaft or the crankcase. Stiffening to the extent of carrying the double-walled structure of the cylinder region right round the crankcase, with closely spaced cross-connections, might give a major reduction of noise. A major reduction of noise should be obtainable by introducing near-critical damping. This could probably be done with the crankcase but it is not easy to see how a "dead" crankshaft could be made.

Current experience is tending to show that in quietening the driving compartment in diesel versions of light commercial vehicles, airborne engine noise does not present the major problem; this applies still more to passenger cars, where sound absorbing material tends to be used freely. The high-frequency components, however, remain important to bystanders, and may be objectionable inside the vehicle when driving near walls with windows down.

NOISE FROM VEHICLES

Without a silencer the exhaust is the strongest source of noise in the whole vehicle. The exhaust noise is produced by the shock release of the combustion gases from the cylinder. The essence of modern silencing is to smooth the audible alternating flow, not by inserting frictional resistances increasing the flow resistance, but by inserting reactances. Silencers of this type include the reflection-series filter, consisting of a number of chambers and communicating tubes, in series. It passes the lowest frequencies and blocks all oscillations above a certain limiting frequency, and is more effective at full throttle than for idling. On the other hand, those known as absorption filters, using porous materials (preferably separated from the exhaust stream by porous partition walls) are more suitable for idling than for full-throttle running; they can be combined with the reflection series filter, or the reflection sidebranch filters. The latter type is effective only over a narrow frequency band and is limited in its application to exhaust silencing. The location of the silencer along the exhaust tract is important because of resonance effects. By a choice of favourable pipe lengths and appropriate silencer reactances it may actually be possible to achieve a gain in power.

When the exhaust is effectively silenced, intake noise may be extremely disturbing. Acoustic blocking resonance filters are usually employed as intake silencers, but unfortunately they have an adverse effect on power output.

Cylinder-block vibrations can be considerably reduced by adequate wall thicknesses, stiffeners, and by good bearings and balancing. Palliatives for gear noise are the use of helical teeth, plastics gearwheels, steel-toothed rims on plastics wheels, and appropriate design of the wheel form. Fan noise, too, can be reduced by good blade design and by their angular setting. Tyre noise can be reduced by employing a profile not too coarsely corrugated.

High-frequency wind noises over the body can be avoided by smooth aerodynamic body form, but another source of trouble to passengers is high-energy vortices entering through open windows.

Rumbling noises, mainly noticeable inside the vehicle, especially with all-steel bodies, are marked with two- and four-cylinder engines, arising from second-degree unbalanced forces. These forces can be reduced to some extent by resilient engine mounting, but rumbling vibrations are not easy to suppress. If the exciting sources cannot be eliminated, the only course is to stiffen the vehicle walls and to cover them with high-damping materials.

Concluding **How to Cross an Unsafe Bridge**

α cannot exceed 1·2277. For values of α less than this, a relation is given between speed and span determined by the condition that the final slope which the vehicle has to climb shall not exceed a certain value. For values of α up to 1·2 and spans up to 50 ft, the speeds lie below 42 m.p.h. for a slope of 1 in 10 and below 30 m.p.h. for a slope of 1 in 5.

The analysis is applicable to actual mild steel bridges, but it is not proposed to seek experimental confirmation.

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PROGRESS OF 50-CYCLE TRACTION TECHNIQUE IN THE CONGO

It is seven years since the opening of the Jadotville-Tenke 20 kV electrification project in the Belgian Congo, which was the first application to commercial railway working of locomotives with single-phase series motors fed with current at the industrial frequency of 50 c/s. Experiments with industrial frequency traction date back to the beginning of the century, and the section of the Hungarian State Railways, from Budapest to the Austrian frontier, at Hegyeshalom, was electrified in 1933 with an overhead supply at 16 kV, single phase a.c. at 50 c/s, but the locomotives converted this input into three-phase current for the traction motors. The Höllenthalbahn electrification in Germany of 1936 was originally experimental, using four different prototype locomotives, and the post-war scheme of the French National Railways, from Aix-les-Bains to La Roche-sur-Foron, inaugurated in 1950, similarly served, in its early years, as a proving ground for four types of locomotive and three types of motor coach. These facts underline the confidence shown by the Bas Congo-Katanga Railway in placing in service as early as 1951 a complete series of 12 locomotives of a single type.

The electrical equipment of these pioneer locomotives was designed and supplied by the Ateliers de Constructions Electriques de Charleroi (ACEC), while La Brugeoise et Nivelles (BN) manufactured the mechanical parts. This combination of Belgian firms has since supplied a further series of ten locomotives with a.c. motors to the same railway, and is now beginning deliveries of ten more locomotives in which the rectifier system of traction has been adopted. The general trend of 50-cycle practice, as exemplified by these three successive locomotive classes for the Belgian Congo, has become of wider interest since the first stage of the Bas Congo-Katanga (BCK) electrification was inaugurated, as the ACEC is one of the group of Continental firms supplying traction equipment for the 50-cycle electrification of the Indian Railways from Burdwan to Moghalsarai.

In the locomotives for the Jadotville-Tenke section of the BCK electrification, the traction motors were of the double-armature type, the two parallel armature shafts being geared to a common gearwheel on a hollow shaft with flexible couplings to the driving axle. One of the double armature motors of this series of locomotives is shown in the third illustration. The two field systems had a total of 20 poles. By the time the electrification was extended to Elisabethville, in 1956, the technique of 50-cycle motor design by ACEC had reached the stage where the desired performance could be provided by 18-pole, single-armature machines arranged for nose-suspension. The previous locomotives had been controlled through tappings on the low-tension side of the transformer, selected by electro-pneumatic contactors, but in the ten new machines placed in service at that time, control by means of a camshaft h.t. tap-changer was introduced. Air-blast main circuit-breakers replaced the oil-immersed type used on the first 12 locomotives, and a static magnetic amplifier was substituted for the rotary amplifier previously installed for the control of braking effort during rheostatic braking. The number of running notches was increased from 15 to 16.

Meanwhile, the general trend of 50-cycle traction practice had moved towards the use of rectifiers and d.c. motors, for while the 50-cycle motor had been the subject of a notable improvement in power/weight ratio and in general sturdiness of construction (of which the use of nose-suspension gave proof), it still compared unfavourably in number of poles and brush sets with the d.c. machine and required special provision for automatic shunting of the commutating poles during the starting period. ACEC had been in close contact with the supply of rectifier equipments for locomotives of the French National Railways on the Lille-Basle electrification line, and the rectifier system has been adopted for the ten locomotives now under construction to meet the additional motive power requirements of the BCK Railway arising from the extension of electrification from Tenke to Luena. This design continues certain features of the second series of locomotives with a.c. motors already mentioned, and embodies various developments in equipment peculiar to the rectifier system of traction. The wheel arrangement is again Bo-Bo, and the ten locomotives with water-cooled ignitron rectifiers now being built weigh 75 tons in working order. Their continuous rating of 2,040 h.p. compares with 1,680 h.p. for the original BCK locomotives which had a.c. motors and weighed approximately 76 tons. A general view of one of the second series of ACEC locomotives is shown in the illustration on the left on this page. The lowest illustration on this page depicts the interior of one of the rectifier locomotives.

Control is again on the high-tension side of the transformer using cam-operated contactors actuated by the Jeumont-Heidmann (JH) electrically-driven camshaft mechanism, which ACEC has supplied for all recent motor coaches and electric locomotives of the Belgian National Railways. Progression to the notch selected by the position of the driver's controller hand-wheel is controlled automatically by an accelerating relay, the operation of which can be regulated according to the load being hauled and to the adhesion conditions by means of a small handle which adjusts a potentiometer in the relay coil circuit. For the guidance of drivers, this control is graduated to show the settings for starting tractive efforts between 5 and 30 tonnes. It can also be manipulated in conjunction with the main control wheel in such a way as to notch the equipment up one step at a time if desired.

On the early notches, the fields of the motors driving the leading axle of each bogie in the direction of running are weakened automatically in order to reduce the tendency to wheelspin due to weight transfer, but should slipping develop, the control equipment notches back until it ceases, after which it notches up again to its previous condition, all without any action being required from the driver. Movement of the control wheel in an anti-clockwise direction from the "off" position selects the rheostatic braking notches, on which the effort is regulated automatically by a magnetic amplifier, as in the preceding series of locomotives with a.c. motors. Forced ventilation of the rheostatic braking resistors comes into action automatically. The combination of motoring and braking notches on the same hand-wheel, and the additional control for virtually stepless adjustment of tractive effort, reflect the driving arrangements in the "123" class, 3,000 V d.c. locomotives of the Belgian National Railways. These locomotives were also equipped by ACEC.

The two rectifier cubicles each contain four ignitron rectifiers, of 8 in diameter, connected

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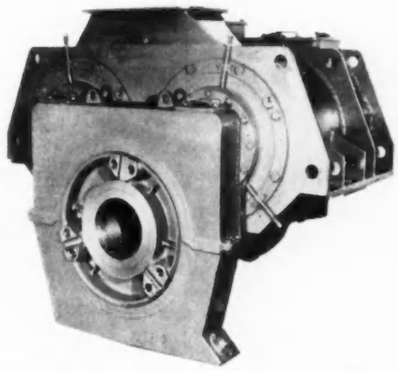
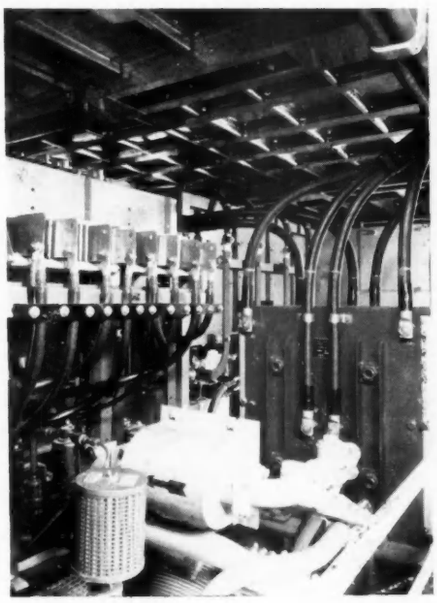
The second series of locomotives had 50-cycle axle-hung traction motors. The more recent rectifier type are similar in outline.



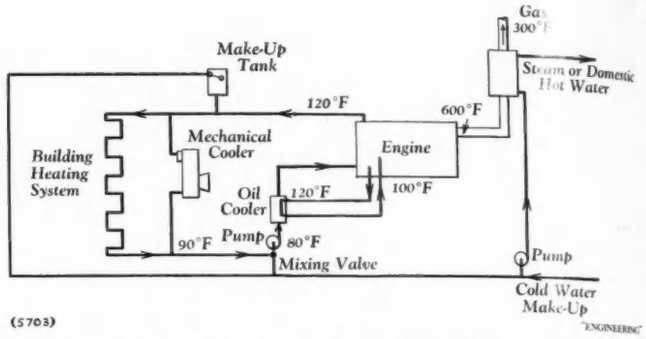
One of the double armature motors of the first series.

Interior of one of the rectifier locomotives, showing the smoothing choke on the right.



Continuing **Design**

WASTE HEAT RECOVERY FROM DIESEL ENGINES



Heat recovery arrangement using engine cooling water for building heating, and exhaust gas for steam or domestic water supply.

In installations employing standby diesel generators, by utilising the waste heat for heating and hot water systems, overall efficiencies higher than 75 per cent may be obtained—and it may therefore be attractive to operate the "standby" generators regularly to supplement the electricity supply system. Examples of waste-heat utilisation were given in a lecture on "Waste Heat Recovery as Applied to Diesel Engines," before the Institution of Heating and Ventilating Engineers in London recently by Mr. R. M. Tufnell, of the Diesel Division, English Electric Company Limited. We give below a summary of Mr. Tufnell's main points.

At full load, the heat which can be recovered from a diesel generator set at full load is roughly as follows:—

	Per cent
Work, allowing for generator losses	37
Jacket water, allowing for heat exchanger losses	21
Oil, allowing for cooler losses ..	4
Exhaust, allowing for efficiency of exhaust gas boiler and minimum temperature at which exhaust will leave boiler	12-18
Giving an overall efficiency of ..	74-80

It is important to lay out the engine-cooling system correctly in the initial stages, so as to keep the oil as cool as possible (about 140° F) and the jackets as hot as possible, with an outlet temperature of 160-180° F unpressurised, or as high as 236° F with a pressurised system.

The jacket water should circulate in a closed circuit, usually through a heat exchanger. Although it is sometimes possible to arrange for a building heating installation to be incorporated as a closed circuit with the engine, the difficulty arises that the return water may be too hot to use in the oil cooler. Using a heat exchanger in series with the oil cooler allows the heat in the oil to be utilised; also, if any draw-off of hot water is required, the cold water make-up can be introduced through the oil cooler, which helps to keep down the oil temperature, and confines the formation of scale to places where it can be easily cleaned.

The heat in the exhaust gas can be used either to drive a supplementary turbine or as a drying medium, but is more usually used in an exhaust-gas boiler or calorifier. The exhaust-gas boiler can be used to increase the temperature of the water passing from the jackets or heat exchanger, or it can have a separate feed. The accompanying illustration shows a typical heat-recovery arrangement using the engine cooling water for building heating, and the exhaust gas heat for steam or domestic hot-water supply. To achieve consistent operation, the generator set output must be kept as near full load as possible, because the exhaust temperature varies with the load.

Domestic hot-water supply may require a large amount of cold-water make-up. A suitable mixing valve is most important to ensure that there is adequate water passing through the system, and alarms should be fitted to give warning of undue temperature rise.

The efficiency of the exhaust gas boiler depends on the temperature of the product and the initial temperature of the exhaust gas. The greater the temperature drop in the exhaust gas, the higher the overall efficiency; and the higher the steam pressure required for the boiler, the higher must be the outgoing gas temperature and therefore the lower the efficiency. Such boilers can also be designed for dual firing using oil or electricity to supplement the exhaust heat—an advantage when the diesel generator set is running at part load.

As yet there is little available operating data in this country on the vapour phase system; in this system, steam is produced direct from the engine cooling water—which is kept slightly above atmospheric pressure—in a separating tank.

At the flax spinning mill of J. and T. M. Greeves Limited, Belfast, a six-cylinder oil engine with evaporative cooling was installed in 1955—believed to be the first large diesel-generating plant so equipped. The heat is dissipated through a waste heat boiler through which also the exhaust gas is passed. The exhaust gases are then led from the boiler to two Lancashire boilers, and in series passed through the feed water economiser, process water economiser and air heater for a drying loft. A separate water circuit supplying the turbocharger intercooler and lubricating oil cooler in series is used for space heating or process hot water. Under service conditions the following heat balance has been obtained:

Heat to work	35·33 per cent
,, steam	29·10 ,,
,, feed water	11·80 ,,
,, process water ..	4·45 ,,
,, air heater	1·72 ,,
,, space heating ..	8·93 ,,
Gross heat recovery ..	91·33 ,,
Allowance for auxiliaries ..	3·33 ,,
Net heat recovery	88 ,,

Another possibility is the use of a heat pump in conjunction with a diesel prime mover. Assuming an overall thermal advantage of 4·5 and an overall efficiency of 32 per cent for the engine and compressor, the order of the heat output in relation to heat input would be:

Heat pump	144 per cent
Jacket heat recovery ..	21 ,,
Exhaust	18 ,,
Total	183 ,,

that is, about three times the normal operating efficiency of the average industrial boiler. The capital cost, however, would be considerably higher. Maximum advantage will be obtained if the plant works on a reversible principle so that it can be used to heat in the winter and cool in the summer.

Concluding Traction Technique in the Congo

in pairs to provide full-wave rectification of the traction motor current. They are water cooled, and the system incorporates thermostatic control to regulate the proportion of water passing through the radiator according to the temperature. The most interesting feature of this part of the equipment is the new design of the smoothing choke, as a result of which the weight of the complete smoothing installation for a locomotive has been reduced to just under 12 cwt. This has been made possible by a technique of special construction using steel wires for maximum utilisation of the core, and forced cooling of a bare copper winding. A motor-driven fan is incorporated in each unit and serves also for cooling the rectifier radiator.

On-load tap-changing with the JH camshaft is effected by means of a transition resistance, which is normally in circuit only while a change is taking place, although it can be kept in circuit for a limited time on five steps of the accelerating sequence, so as to provide an extra-fine gradation of tractive effort. The complete control scheme comprises 20 main running notches, five resistance notches with a short time-rating, and three weak-field notches. Application of the JH system to a.c. control has resulted in a remarkably compact and accessible arrangement. Only four cam-operated contactors break current and these are of the normal air-break type with arc chutes. The remainder are concerned with selection only and are oil-immersed, which enables them to be of small size and closely spaced.

All auxiliary machines are driven by three-phase motors supplied from an Arno phase-converter which also drives a d.c. generator for battery charging. Instead of having to be run up to speed by motoring the generator, the Arno set in the ACEC system is self-starting; the auxiliary phase being used as a starting winding.

The next step will be the use of semi-conductor power rectifiers in place of ignitrons. A further locomotive similar to the present series is to be built and equipped with air-cooled silicon rectifiers, after which two more locomotives of a new series, weighing only 60 tons each, also with silicon rectifiers, are on order. It seems probable, therefore, that the history of 50 cycle traction will record the Bas Congo—Katanga Railway as a pioneer, not only in the use of industrial-frequency a.c. motors, but also in the use of the type of semi-conductor rectifier which at present offers the most interesting possibilities in its class for railway traction. The originality in electrical design matters shown by the ACEC concern has already been made evident. The facilities of the Ateliers Metallurgiques de Nivelles are equally impressive. At the latter works, the "flow" production procedure includes the pre-assembly and wiring of a "false" chassis incorporating the bulk of the cabling. A test track over 380 yd long, with permanent catenary capable of being energised at any voltage and frequency, is available for final adjustments to finished locomotives.

Marketing

Training the Customer

The creation of enough knowledge among their customers to run and maintain specialised plant and equipment effectively has always been a major problem for engineering companies. Unless they are able to solve it much progress is unlikely, for a user will tend to condemn what he does not understand, with a consequent endless sequal of troubles requiring service visits from the manufacturer. Very quickly this becomes an unbearable strain and customer relations take a turn for the worse. When the product is a new one the need to spread understanding and to induce a spirit of co-operation among users is a prerequisite of success. Some firms have made it the reason for a much closer relationship with their customers than could otherwise have been established, with considerable benefits to sales.

A very good example of this, although in a somewhat wider context, is Holman's school for mining engineers at Camborne. Young men from all over the world get instruction in the use of pneumatic tools from the technical staff of this company. They take back to their industries an intimate knowledge of a friendly organisation whose expertise in drilling and mining techniques they remember when the time comes for them to exercise an influence over their company's choice of plant and equipment. There are many other examples, most of them more directly concerned with training in the use, or installation of certain equipment. In instrumentation this is particularly important. Foxboro-Yoxall have recently expanded the training facilities started in 1951 " to meet the growing demand for training from customers." Despite the limited accommodation available, 700 people received training in less than seven years, one in ten from overseas. Now a training school has been opened at the company's new Redhill factory with much improved facilities. Each student has a bench equipped with compressed air and electrical supplies. Full ranges of Foxboro-Yoxall equipment are provided for the student to dismantle, reassemble, calibrate and adjust under typical conditions.

The approach is individual and the number of students limited to nine for each of these courses. A maintenance course is designed to give instrument mechanics practical training in the use and maintenance of the company's equipment. An advanced instrument course for instrument engineers covers the theory of control instrumentation and its application to industrial processes. Special courses relating to particular user industries are given from time to time. Two were held recently, one on instrumentation in the paper industry and the other on the control of coal washing plants. Another recent course was given in the German language. There could be found few better ways of getting customer goodwill and, incidentally, customer-consciousness among manufacturer's staff.

Export Sallies

The season for overseas tours by senior company executives is already with us. Frank Perkins, chairman and joint managing director of F. Perkins Limited, has recently carried out a visit to Turkey, Greece, Malta and the Middle East, where nearly 40,000 Perkins diesel engines have been sold. He was accompanied by John Collins, the company's export sales manager, and with him visited Perkins distributors in each country and watched Perkins engines operating in a wide variety of applications under local conditions.

In quite a different field, Robin MacLellan, managing director of George MacLellan and Company of Merryhill, Glasgow, has spent the whole of October in Canada and the United States, taking with him the company's sales manager, David Johnstone. Mr. MacLellan is a great traveller—he has averaged over 20,000 miles a year over the past seven years—and fully lives up to the concept that the creation of sales dynamism is a managing director's job. MacLellan's have built a reputation for an ability to produce new products which sell: their " Sea-Esta " air beds, Roll-a-Boats, and now a rubberised golf bag, have helped to keep them to the forefront of developments in the rubber industry and proved useful adjuncts to the sale of hose pipe, conveyor belting, rubber mechanical goods and protective clothing, which are the company's traditional products.

Others have also left for extensive world tours: J. P. Craig, sales director of Rotary Hoes will visit New Zealand, Australia, South and East Africa—mainly by ship and road. William Barbour, export manager of the Bergius Company, Glasgow, manufacturers of the Kelvin range of diesel engines, left for the Persian Gulf, the Far East, and Australasia. The company export 70 per cent of their annual output of 600 engines (30,000 b.h.p.) and close relationships with overseas customers and agents are vital. Many more are abroad or on their way. Early fogs may become an additional incentive—the country's export need is, or should be, incentive enough.

Guide to Exports

The General Electric Company have been officially congratulated on their quarterly publication on export markets. The President of the Board of Trade, Sir David Eccles, points out in a message published in its October issue (Vol II, No. 5) that *Export Guide* was launched at a time when the market for British exports was continuously expanding: to-day world markets are more competitive and exporters " will need more than ever to be aware of changing conditions overseas and alive to the opportunities available." Sir David's comment on GEC's publication, that it provides in a compact and graphic way just the pointers to market developments that exporting firms must be looking for, is well deserved. So, incidentally, is the guide's circulation which in two years has jumped from 5,000 to 15,000.

The review of current export trends contains a warning: that competition from Western Germany and Japan has intensified, and that British exports are proving particularly vulnerable to this competition. Also an admonishment: that Britain's export business since the war was hampered by two defects: " too much effort was directed towards the relatively static sterling area and too great an emphasis was initially placed on consumer goods." Now we are paying for these defects and likely to go on doing so until they have been corrected further. Luckily export prospects in Australia and South Africa are improving but they are bad or deteriorating in too many of our traditional markets.

Representation Abroad

Leyland have recently appointed additional agents and opened new service depots overseas to strengthen further their already considerable hold on export markets for heavy vehicles. In South Africa two new depots have been opened by Leyland Albion (Africa) Limited, at Pietermaritzburg in Natal and Eshower in Zululand. In Peru, new agents, Milne and Company S.A. of Lima, have been appointed to handle the products of Albion Motors and Scammell Lorries. In Thailand, Henry Waugh and Company of Bangkok have been appointed for Leyland trucks, buses and industrial engines. In India, Ashok Leyland of Madras have been appointed agents for Scammell.

Dynamic Selling

A timely reminder to top management that they can never escape the responsibility for selling their company's products was given by Sidney Roberts, managing director of Hoover Limited, in an address to the annual conference of the Incorporated Sales Managers' Association held in London recently. He put the onus of effective selling squarely on the shoulders of the chief executive: " too often it has been assumed that this responsibility has been discharged by the establishment of a virile sales department as if sales activity were a separate watertight function. In fact it is the managing director's task to create and direct an integrated selling organisation, tuned to market needs, which encourages all functions—research, design, production, administration and marketing."

Mr. Roberts warned against the danger to British firms of developing along orthodox and traditional lines. Deep economical, political and social changes are taking place, and there is a need for continual analysis of trends and long-range plans to meet them. He advised against " change for the sake of change." The emphasis is now no longer on the productive effort but on the cost reductions necessary to maintain our place in world markets: " to this end firms must specialise more. Design must be in need of simplification. New features which are mere refinements burden the production unit and retard cost reduction." Above all it is the managing director's task to create " sales dynamism as a corporate thing, shared by all—executives, managers, workpeople." Fittingly enough, Mr. Robert's theme was on " alerting management for a salesmanship economy."

Supreme Grand Prix

The highest of all awards for exhibits concerned with the exploitation of nuclear energy at the Brussels Exhibition has gone to a British firm, the Nuclear Power Plant Company of Knutsford, Cheshire. Theirs was the largest exhibit on show in the British Pavilion—83 ft by 58 ft—and consisted of a model of the 400 MW station which NPPC are building for the CEGB at Bradwell, Essex.

The award is no mean tribute to British inventiveness and applications. It is of the greatest significance in the competitive struggle now building up between the leading atomic powers for the lead in world markets.

Book Reviews

PLANNING BY MATHEMATICS

Linear Programming and Economic Analysis. By ROBERT DORFMAN, PAUL A. SAMUELSON and ROBERT M. SOLOW. *McGraw-Hill Book Company Incorporated, 330 West 42nd Street, New York 36, N.Y., USA* ($9·50); and, *McGraw-Hill Publishing Company Limited 95 Farringdon Street, London, E.C.4.* (77*s* 6*d*)

Most of us have preconceived ideas about the sort of problems for which a mathematical approach is profitable. If we are faced with a complicated problem in elastic stress analysis, for instance, we instinctively expect a mathematical solution to exist, and accept it without qualms if it can be found. Experience has taught us that this is a field in which mathematics is a useful and respectable servant. If, on the other hand, the mathematician starts telling us how to run our business, how to win at poker, or how to organise a railway goods yard, our instinct rebels at such an insult to our common sense. These activities, we feel, are the preserves of practical experience, inspired guesswork, and all the other qualities which distinguish man from the humble computing machine. The fact remains, however, that towards the end of the 1940's the United States Air Force began to feel that mathematics might be of use in planning the complicated patterns of activity necessary in modern warfare. They therefore sponsored a study which laid the foundations of the subject now known as linear programming. At about the same time other mathematicians were developing the related subjects of game theory and dynamic programming in their efforts to solve other problems in the field of economic and industrial planning. (It should be noted that the word " programming " is used here with its normal meaning of " the planning of related activities." It has no connection with automatic computing machines.)

Whenever we attempt to apply mathematics, it is always necessary to construct a mathematical model or abstraction of the real-life problem. The model must be simple enough to allow solutions to be found, while if the solutions are to be relevant the mathematics must reflect all the important features of the real problem. The model which forms the basis of linear programming is the mathematical problem of minimising a linear function of a number of variables, where the variables have to satisfy a set of linear inequalities. A classic example is the transport problem, where given amounts of a certain product have to be delivered to a number of consumers. The product is manufactured in a number of factories, and the problem is to find the cheapest way of supplying the required amounts to the various destinations. The variables, which represent the amounts sent from each individual factory to each destination, obviously have to be positive, and must also satisfy inequalities derived from the maximum productive capacities of the various factories. The function to be minimised, which is here the cost of transport, may be thought of as an approximately linear function of the amounts despatched. Thus the problem is essentially a linear programming one.

Having defined the central mathematical problem, we see that the subject of linear programming falls naturally into two parts. The first is purely mathematical, and deals with the analytical and computational problems of solving the algebraic model. The second is concerned with the relation of the model to real-life problems, and the effect which discrepancies may have on the value of solutions obtained from the model.

The relevant disciplines involved in the mathematical theory of linear programming are matrix algebra and multi-dimensional vector geometry. Since these disciplines have usually been thought of in the past as " pure " rather than " useful " mathematics, any author writing for a wide audience must teach his readers a certain amount of fundamental mathematics before he can come to grips with his problem. The authors of this book evidently feel this need. There is an appendix on matrix algebra, and throughout the text pains are taken to keep the mathematics as simple as possible.

Although most of the basic mathematical theory is covered, the authors are writing for economists, not mathematicians. Their main concern is to show how problems in economic theory can be solved by linear programming, and the general reader who wants to know what linear programming is must extract his answer from a great deal of economics. Incidentally, one omission of importance is a discussion of computational problems. Two or three-variable problems may suffice to illustrate a theory, but a real-life linear programming problem may involve 50 variables and 100 inequalities. It would be useful to have some guidance on the computing effort necessary to solve such a problem, and the numerical difficulties which might arise in the process.

The book is largely concerned with relating the linear programming model to various economic models, and there is little discussion of the approximations inherent in the economic theory itself. The first few chapters describe simple situations, such as the transport problem mentioned earlier, which are easily stated in linear programming terms. The authors then deal with non-linear programming problems (that is, problems in which the function to be minimised is not linear in the variables) and the Leontief input-output model of industrial economy. This is followed by a discussion of time-dependent problems, such as investment programmes, and the final chapter discusses the close relationship between linear programming and game theory. The bibliography reflects the fact that the subject has been developed almost entirely in the United States.

The length of this expensive and carefully produced book is largely due to the many examples which are introduced to illustrate the theory, and the exhaustive way in which these examples are discussed. It is unfortunate, however, that they are all " text-book examples." One longs to be told about just one real-life problem in which the application of linear programming gave an answer measurably better than the results of human guesswork ! It is perhaps unfair to wish that the authors had written a book with less emphasis on economics, but its value for the general reader and the engineer would have been greatly increased by a discussion of the many problems, ranging from the construction of railway timetables to the plastic design of steel frameworks, for which the linear programming model is relevant.

Dynamic Programming. By RICHARD BELLMAN. *Princeton University Press, Princeton, New Jersey, USA* ($6); and *Oxford University Press, Amen House, Warwick Square, London, E.C.4.* (42*s*)

While linear programming deals with the problem of finding the " best " values to be assigned to a set of variables, dynamic programming is concerned with choosing the " best " policy in a situation requiring a sequence of decisions. Each " choice " may be defined by giving a value to a variable at a particular instant of time, so that the complete policy is defined by the values of this variable as a function of time. As in linear programming, one tries to find the function which maximises some quantity defining the " value " of the policy. The quiz contestant who has to decide whether to continue answering questions is a rather trivial example of a person faced with a dynamic programming problem. Although the analogy is not exact, one might compare a linear programming problem with an elliptic differential equation, in which the solution at a given point depends on conditions at all other points in the solution region, while a dynamic programming problem is analogous to a hyperbolic differential equation, in which the solution gradually develops with the passage of time.

This book is very different from the one reviewed above. Although the author describes some of the ways in which multi-stage decision problems arise, his main aim is to present a unified mathematical treatment of his subject. This treatment is based on the theory of functional equations, and is closely related to the calculus of variations. The book is written for the mathematically adult reader in the sense that the language of pure mathematics, where suitable, is used without apology. The arguments, however, are carefully and clearly presented.

Even more than in the case of linear programming, this subject is so new that it is very difficult to judge how far it will develop or what its final practical value will be. This book consists almost entirely of the author's own research work, and represents, as he says, a limited exploration of a " vast untamed jungle of difficult and significant problems." It is seldom restful to travel hard on the heels of an explorer, but difficult not to catch some of his enthusiasm.

MISSING LINKAGE

Kinematisch-getriebeanalytisches Praktikum. By RUDOLF BEYER. *Springer-Verlag, Reichpietschufer 20, Berlin W.35, Germany.* (28·50 *DM*).

It is doubtful whether more than one man in this country is at present capable of reviewing adequately a book by Professor Beyer on kinematics of linkages; this is a measure of the almost total neglect of this subject in the universities, despite the notable work done in this field by Cambridge mathematicians in the last century. To-day almost all original work is coming from the German and American schools of kinematic thought.

Few books on kinematics make clear how the theory which they develop may be applied to practical problems, and in this book Professor Beyer, from the wealth of his experience, has set out to write a companion volume to the standard text books such as his own earlier works. In this volume numerous classified practical problems are examined, the relative theory briefly summarised, and the solution of the problems demonstrated. References are given both to German and American sources, and include work published as recently as the spring of 1958. In addition to the worked examples, a large number of problems are also given for solution, often with hints, and the book is clearly intended for use in appropriate specialised courses in the German technical universities.

This is a book which it would repay a young man handsomely to translate; he would achieve a wide education in kinematics in the process. Whether it would also pay a firm to publish that translation is unfortunately more doubtful, although many designers would find it invaluable.

NUCLEAR AMALGAM

Uranium and Thorium. By L. GRAINGER. *George Newnes Limited, Tower House, Southampton Street, London, W.C.2.* (35*s*)

The Effects of Radiation on Materials. Edited by J. J. HARWOOD, HENRY H. HAUSNER, J. G. MORSE and W. G. RAUCH. *Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N.Y.* ($10·50); *and Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (84*s*)

Zone Melting. By WILLIAM G. PFANN. *John Wiley and Sons Incorporated, 440 Fourth Avenue, New York 16, N.Y.* ($7·50); *and Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (60*s*)

The Effects of Furnace Atmospheres on the Sintering Behaviour of Uranium Dioxide. By A. HUBERT WEBSTER and NORMAN F. H. BRIGHT. *Mines Branch Research Report R2. Department of Mines and Technical Surveys, Ottawa, Canada.* (25 *cents*).

Books on metals are usually termed "Monographs." As such they have aspired to scientific eminence, and ordinary readers with a moderate technical knowledge have found the heights rather forbidding. In his "duograph" on uranium and thorium, Mr. Grainger who happily in the brief space since publication of his book has advanced from chief metallurgist to deputy director of the Research and Development Branch of the UKAEA has avoided this, and aided by his beautifully lucid style has written a book which with very few exceptions is extremely easy to read and understandable to the qualified reader of any profession. The book, however, achieves more than this, it provides most of the basic facts on the important phenomena relating to the two metals, which are of such importance to atomic energy, and, at its commendably low price forms a useful work of reference to any one not in need of the more detailed aspects.

Both metals are dealt with in the same logical sequence of occurrence, concentration, extraction (though without thermodynamic data) fabrication and properties. Its more complex structure, greater importance in nuclear energy and greater familiarity have demanded for uranium and its more important compounds a much fuller treatment than thorium has received. The author's enthusiasm in this matter has, however, led him into a description of the textures resulting from deformation of uranium which may confuse the lay reader and is not wholly clear to the expert. In a new edition a simpler treatment more in keeping with the rest of the book would be an advantage.

The latter part of the book comprises a most interesting account of the use of the two metals as nuclear fuels and a description of the more important types of fuel element including that of Calder Hall to which the author has made a noteworthy contribution. The book ends where all good fuel elements go, in the chemical processing plant. There is an adequate index and a fair bibliography covering works from many countries.

CHANGES DUE TO RADIATION

The fate of Mr. Grainger's two metals, together with almost every other conceivable material in the nuclear reactor is the subject of *The Effects of Radiation on Materials*. This book is a symposium, each chapter written by a separate author, and though its four editors have done their work very well the differences in style and treatment are apparent. Thus while Charlesby in the chapter dealing with polymer irradiation shows a fundamental approach and complete mastery of the subject, which indeed he has largely created, Billington in dealing with metals and alloys attempts to cover too large a subject in too short a treatise, and is reduced to the production of a mass of detail.

The book is an excellent work of reference, there can hardly be an irradiation experiment or a material which is not touched on in some way and the very adequate index, and enormous list of references and bibliography render it essential for the student of irradiation. It is to be hoped that future editions with bibliographies kept up to date will continue to fulfil this service. Not only does the book cover materials, metals dielectric solids, organic compounds and salts, but it also deals with the principles and the experimental techniques of irradiation. To the casual reader the chapter on the experimental approach is the most interesting. It abounds with practical advice to those engaged in this exacting pursuit, and some very sound statements on the principles to be adopted in choosing and operating reactors and irradiation techniques. As an illustration of the wide scope of the book, 26 pages and 119 references are devoted to the physical metallurgist's delight, Semi Conductors.

CRYSTAL PURE

The use of semiconductors as transistors provided the impetus required for the development of zone melting. This fascinating technique has just reached the status meriting publication of a book. It is fortunate that the man who first described zone melting, and has been so intimately concerned in its development should have found time to be the author. Zone melting utilises the difference in composition of a freezing crystal from its liquid to purify a material by passing a short molten zone along a charge of solid.

The book as might be expected from its author is fundamental, detailed and thorough. The early chapters deal not only with theory but also present the relations derived in conveniently usable form. The later parts proceed in logical progression to the many and ingenious techniques which have been invented to apply the theory, the applications, the development of continuous processes and such related topics as crystal growth, concentration perturbation and temperature gradient melting.

There is an adequate index and the references, which must include almost all published work, are drawn from both European and American sources. The newness and rapid growth of the subject render a bibliography unnecessary. The book is essential to anyone who wishes to make use of zone refining or to the student of metallurgy or physics who wishes to improve his knowledge of technique, principles and applications.

PROMISING REACTOR FUEL

The last work considered here is of an entirely different nature to the other three. The Research Reports of the Canadian Department of Mines are designed to survey only a limited aspect of a restricted field. Even allowing for this their cost is extraordinarily low. Uranium dioxide is assuming pre-eminence as a reactor fuel, and for the majority of its applications is required in a massive form for which cold pressing and sintering is the preferred manufacturing technique. The composition of the dioxide is variable, extending from stoichiometric UO_2 to approximately $UO_{2\cdot32}$. The stoichiometric variety is preferred as a fuel on the grounds of strength, stability and retention of fission products, but is more difficult to fabricate since it must be heated to about 1,800° C for satisfactory sintering whereas $UO_{2\cdot2}$ will sinter at about 1,450° C. The authors of this paper describe interesting experiments which demonstrate this and show that, under their conditions at any rate, it is necessary to sinter at a high oxide content and later reduce in order to obtain satisfactory densities at managable temperatures. They have worked out a procedure which includes sintering in steam, and later adding hydrogen which produces the desired result. Other methods are of course possible. The paper is well written, closely reasoned and will be of interest to those in all countries responsible for developing methods of making oxide fuel elements cheaply.

On the Shelf

By Frank H. Smith

I have mentioned before the forthcoming revisionary supplement to the OED and with the autumn number of OUP's *The Periodical* is enclosed a list of abbreviations and works from A-Ak for which a tentative date of origin is given. Sleuths are invited to offer previous quotations to those listed. Anybody who is interested (and it really is an engrossing pastime) should get in touch with the Editor, Oxford English Dictionary Supplement, 40 Walton Crescent, Oxford.

One of the most voluminous and painstakingly compiled bibliographies that I have seen for a long time has been compiled by the Assistant Librarian of the Institution of Production Engineers, Mrs. Beryl Board. The subject is "The Effect of Technological Progress on Education" (a reversal of the usual sequence of events) and a foreword says "An asterisk against an entry signifies that the compiler has not yet read the article." Never before have I seen an implication in a bibliography that the compiler has even seen any of the items let alone read them.

A firm of industrial artists and consultants—Messrs. Hayward and Martin Limited, of 34 High Street, Bromley, Kent—offers a service which helps firms with no publicity department of their own. Hayward and Martin have complete facilities for the preparation of material such as technical handbooks, the various types of draughtsmanship inseparable from engineering work, exhibition displays and so forth. Electronics work is a speciality of the firm. Should a client already have a department but need an emergency service, Hayward and Martin second members of their staff to ensure sympathy of ideas. Their telephone number is RAVensbourne 6702.

The Scientific Film Association has moved to new offices at 3 Belgrave Square, London, S.W.1. This address may seem familiar to some readers and they are quite right. It is in the premises recently taken over by Aslib (and I am not going to expand those initials). SFA's 1958/9 programme is ready and may be obtained from the address given or by ringing BELgravia 6188.

Consultants Bureau Inc. (227 West 17th Street, New York 11) announce a translation from the Russian of 75 papers on "The Structure of Glass." Twenty dollars seems to be quite a reasonable price to pay for something from Russia that you can see through. In their press notice the Bureau states "'The Structure of Glass' is a detailed evaluation of current progress in study of the glassy state." No comment!

One of the beauties of being abysmally ignorant (there are many and I know most of them from experience) is that whatever piece of reading matter you pick up contains material that comes as a complete and pleasant surprise. I did not even suspect that platinum played any part in the glass industry until I saw the pamphlet "Platinum in the Glass Industry—a General Survey," by Dr. H. Moore of the University of Sheffield. This is published by the Mond Nickel Company Limited, Thames House, Millbank, London, S.W.1, and I know I need say no more to persuade anybody interested in glass (as a technology and not as a container for the hop) to write for a copy.

Application to the City Librarian and Information Officer, Central Library, Surrey Street, Sheffield 1, will bring a gratis copy of Research Bibliography No. 65, "Comparisons of Plastics with Steel." This contains nine literature references published since 1953 to discussions on plastics as competitors of steel. In view of the origin of the bibliography I hope there is no bias (and I hope stainless plastics can take a better edge than stainless steel). Out of consideration for the Sheffield ratepayers I would suggest that applicants enclose a stamp.

Production

INTERNATIONAL PRODUCTION ENGINEERING RESEARCH

By D. D. Morgan, A.M.I.MECH.E.*

Leading authorities in the field of production engineering research in many different countries attended the general assembly of the International Institution for Production Engineering Research (CIRP†), which was recently held in Britain for the first time. Countries represented included Australia, Belgium, Britain, Czechoslovakia, Finland, France, Germany, Holland, Sweden, and Switzerland. Previous assemblies have been held in France, Belgium, Germany, Italy, Holland and Sweden.

At the end of the assembly, Dr. D. F. Galloway, director of the Production Engineering Research Association of Great Britain, was elected vice-president of the Institution for the ensuing year, and he will officiate in this capacity at the 9th General Assembly to be held in Switzerland in 1959.

The International Institution of Production Engineering Research was formed in 1949-50 when the four founder members‡ decided to establish a common meeting ground on which scientists in the field of production technology could discuss their problems freely in an atmosphere of mutual trust and confidence. Production engineering research workers from 14 different countries now report their findings to the Institution, which thus plays an important role in the evolution of improved production techniques in many parts of the world. To ensure the highest standards of reporting and discussion, senior membership of the Institution is restricted to not more than four leading authorities in the field of production engineering research in each country. The Institution has for one of its main objectives the removal of barriers to effective communication between production engineering research workers in all parts of the world, and to this end is compiling an international dictionary of production engineering.

METAL CUTTING RESEARCH

During the assembly over 30 papers were presented on recent researches in many fields of production. Subjects discussed included the properties of spark eroded surfaces, a method of measuring machinability, machine-tool scales with optical reading devices, testing cemented carbide tools, the performance and wear characteristics of ceramic tools, deep drawing, hydraulic power transmission and its possible application to machine tools, investigating machine tool vibration by means of models, the effect of temperature variations on the accuracy of measurements, residual stress measurement as a means of distinguishing manufacturing methods, and the control of machine tool testing procedure.

Because of space limitations, it has been possible in this report to refer to only a few of the papers presented, many of which described significant contributions to the improvement of production techniques and to the advancement of production engineering research. Arrangements are being made by CIRP for the publication of all papers in due course.

In a cogently reasoned paper on the strategy of metal cutting research, Dr. Eugene Merchant (United States) stressed that the challenging problems of the future should be solved by means of a unified research attack, both basic and applied, in which the physical sciences as well as engineering principles should be employed. Dr. Merchant showed that a fourfold increase in material strength can produce a tenfold increase in machining costs. As new materials are being continually introduced in response to the demands of product designers for higher strength and more heat-resistant materials, especially in the aircraft industry, intensive research into the machining of these materials is clearly essential if production costs are not to rise steeply. How such a unified research programme reduces machining costs was illustrated by reference to a variety of work carried out in the laboratories of the Cincinnati Milling Machine Company, United States.

Dr. Merchant rightly stressed that the prime target in research to improve metal cutting technology must be machining costs, and argued that the key factor in controlling costs in the actual process of removing metal is rate of tool wear. Much of the metal cutting research programme of the author and his colleagues has therefore been oriented in this direction. The techniques and equipment used include explorations of the details of the structure of diffusion zones formed artificially by heating tool materials and work materials in contact at high vacuum; tool life tests using tools irradiated with radioactive tracers; optical emission and X-ray spectrograph; the high speed camera; and the electron microscope. Various other aspects of cutting tool performance and of the research methods employed were also described.

Although the techniques and equipment used in metal cutting research in this country have also been brought to a high pitch of development since the war, all the available evidence indicates that the problems of reducing machining costs are being much more intensively attacked in the United States than in Britain, where the total expenditure on this type of research is still relatively small. The United States, Dr. Merchant stated, is preparing to machine the "unmachinable routinely." In this country, as experienced observers have repeatedly pointed out, too many companies are still not machining economically even the readily machinable. It should be unnecessary to point the moral of the disparity of the production engineering research effort in Britain and the United States, or to underline the threat it presents to this country's future.

CERAMIC TOOLS

Two useful additions to the growing literature on the performance and characteristics of ceramic tools were contained in papers presented by E. J. Krabacher (United States) and J. L. Remmerswaal (Holland). The researches described by Krabacher included the turning of steels, cast iron, and non-ferrous materials, and the high-speed milling of cast iron and certain non-ferrous materials such as pure nickel. A particularly interesting result was that steels such as AISI 4340 and AISI 1018 were successfully milled with ceramic tools at 2,000 f.p.m. under controlled laboratory conditions. Good tool life was obtained with no major evidence of serious chipping. Good results were also obtained with some of the ceramic tool materials tested when milling cast iron and nickel at high cutting speeds. The results of the turning tests indicated that certain ceramic materials may give better performance than cemented carbide and cermet tools when properly applied in operations on steels, cast iron and many non-ferrous materials. Throughout the investigations, particular attention was given to tool geometry and to the rigidity of the set-ups employed. Krabacher confirmed that not all commercially available ceramic materials perform equally well, and his tool-life/cutting-speed curves showed a wide spread in performance, even when two commercial materials, which failed in less than two minutes at 500 ft/min, were excluded. Krabacher's results emphasise once more the hazards of drawing conclusions about the performance of ceramic tools in their present stage of development unless the conclusions are specifically related to the tools tested.

An investigation into the performance of ceramic tools when machining cast iron described by Remmerswaal was carried out at the Centrum voor Metaalbewerking of the Metaalinstituut T.N.O. (Centre for Metalworking of the Metal Research Institute T.N.O.), Delft, Holland. This organisation is financed partly by the Netherlands Government and partly by a number of Dutch firms, and its constitution is thus similar to that of the Research Associations in this country. Remmerswaal showed that even with the machine tools generally used at present in Holland, the particular types of ceramic cutting tool used in his main tests offer considerable advantages over cemented carbide cutting tools when turning pearlitic cast iron. But as Remmerswaal also pointed out, there are considerable differences in the quality of tools at present available. Various other aspects of the performance of ceramic tools, including the influence of higher cutting speeds, are being investigated by Remmerswaal.

CHIP FORMATION

During the past 20 years, several metal cutting investigators have devoted considerable attention to the study of chip formation processes. Some of the most important of this work has been carried out in the laboratories of the Cincinnati Milling Machine Company, USA, and one of the company's recent investigations was described by B. N. Colding (United States) in a paper on a yield criterion applied to the shear-angle relationship. Colding briefly summarised the various shear angle relationships which have been proposed by other research workers and pointed out that except for Weisz§ all have assumed that the work material is isotropic. Colding's analysis takes into account the influence of the anistotrophy of the work material and, indirectly, the dependence of the shear angle relationship on the feed. The shear stress along the shear plane was found to be independent of rake and cutting speed to a good degree of approximation. This stress varied with the logarithm of the inverse value of the feed.

* Information Manager, Production Engineering Research Association.

† The Institution is so referred to on the Continent from the initial letters of its original name.

‡ Dr. D. F. Galloway, director of PERA. Ingenieur General P. Nicolau, director of the Institute Supérieur des Matériaux et de la Construction Méchanique (ISNCM) (France). Professor E. Bickel, Ecole Polytechnique Federale de Zurich (Switzerland). Professor O. Peters, Université de Louvain (Belgium).

§ Weisz, M., "Étude Métallographique de la Formation du Copeau d'Usinage," l'Institut du Récherches de la Siderurgie, Serie A-No. 42, Février, 1957, Saint German-En-Haye, France.

In a brief but interesting paper on the properties of spark-eroded surfaces, M. Barash, of the Manchester College of Technology, suggested that of the three theories currently advanced to explain the phenomenon of erosion by electric spark, the best explanation is offered by the theory of thermal action. On the basis of this assumption, he has deduced a number of conclusions about the expected geometrical and physical properties of the eroded surfaces and has carried out appropriate experiments. A theoretical prediction about the capacity/surface finish relationship has been confirmed by experimental results. Although certain workers have declared that stylus instruments are unsuitable for assessing the finish of spark machined surfaces, Barash suggested for purposes of industrial comparison that stylus instruments can be used provided reasonable care is taken to avoid stylus damage. The author reported that he has obtained clear evidence that spark erosion gives rise to residual tensile stresses in the eroded layer of annealed mild steel strip and hard rolled brass. Experiments carried out to determine the effect of spark erosion on the endurance of mild steel normalised prior to machining, showed that the endurance limit of spark eroded surfaces was about 15 per cent less than that of turned ones. Barash is continuing his investigation into fatigue to analyse the influence of geometry and of residual stresses.

A method of measuring cutting forces in the frame sawing of wood, described by Dr. E. Kivimaa of the State Institute for Technical Research, Finland, should lend itself, with some slight modifications, to the investigation of band and circular sawing. Basically the method consists of determining the components of the cutting force by measuring the reacting forces generated in the wood being sawn.

A useful, though at this stage, necessarily tentative analysis of the basic mechanics of grinding wheel wear and self-dressing was presented by J. Koloc (Czechoslovakia) in a paper on the life of grinding wheels. Some useful conclusions about wear and self-dressing can be drawn from the analysis which, however, still requires further refinement by practical research.

Difficulties experienced in distinguishing between the bond and grains of grinding wheels with a vitrified bond have been overcome by means of a technique developed by M. J. C. Matthijsen at the Centrum voor Metaalbewerking T.N.O. at Delft. This is based on the use of a super-high-pressure mercury vapour lamp without an ultra-violet filter. When the light from the lamp was cast directly on to a grinding wheel, an apparent discoloration occurred which was clearly distinguishable, the grains turning blue and the bonding medium being seen as a yellow to yellowish-green discoloration. This can be explained by the fact that the two components of the grinding wheel have different reflection coefficients in the mercury sharp-line spectrum.

METROLOGY

M. Ehrenreich gave a short account of experiments, carried out in the General Mechanical Engineering Laboratory of the Technion, Israel Institute of Technology, Haifa, in which the surface texture of bored cylinders was measured by means of bearing area curves. In the course of the investigation, apparatus was developed for simplifying and speeding up the drawing of the bearing area curves. Ehrenreich's evaluation was based on the slope of the curves. Useful comments on turning and honing cylinder bores, and on wear during running-in, based on the results of the investigation, were made by the author. He claimed that the curves gave a clearer and more comprehensive picture than the CLA method.

In recent years there has been a growing demand for improved methods of measuring the sizes of large workpieces up to 20 or 30 ft in diameter, in contrast to the practice of "matched fitting," in which the finished dimensions of mating parts are made relative to each other rather than to absolute standards of measurement. Considerable interest therefore attaches to an account of two new measuring machines for lengths up to 30 ft given by Dr. F. H. Rolt, C. Godfrey, and S. C. Bottomley (all of Great Britain). The machines have been designed primarily to facilitate the direct measurement of the length of pin and rod gauges. One type has capacities of 80 in and 120 in and reads direct to 0·00005 in; the second type is for lengths exceeding 120 in or where the higher accuracy of the first type is not required, and reads direct to 0·0001 in. These machines incorporate their own bases of measurement in the form of calibrated scales or tapes.

Machine tool scales with optical reading devices were discussed in a paper by Godfrey and Bottomley. In order to illustrate their advantages the authors referred to a number of interesting examples of machines fitted with scales and optical reading devices. Reference was also made to various types of small scale-reading projectors which have been developed for fitting to existing machines as attachments, or for building into machine tools by the makers. Some specially designed projection units are being fitted to machines which have been redesigned to accommodate projection units and scales. The authors also describe a simple type of optical scale reader which has recently been developed for high grade open scales.

GAUGING UNIFIED SCREW THREADS

The effects of different gauge addenda on the performance of "Not Go" screw plug gauges for Unified Screw Threads were considered in a paper by G. Lorenz of the Division of Metrology, Commonwealth Scientific and Industrial Research Organization, Australia. The introduction of the Unified Screw Thread System in Australia has been accompanied by difficulties caused by the conflicting results obtained by the different practices adopted in Britain and the United States for controlling Unified Threads, especially in the design and use of "Not Go" screw plug gauges for checking internal threads. Both practices are in use in Australian factories and have led to differences in the tolerances actually permitted in production. Investigations which Lorenz carried out into the criteria for acceptance and rejection performances of the British, American and proposed British "Not Go" screw plug gauges showed that gauges with longer thread flanks gave a lower rejection rate, and allowed a considerably greater malformation of the thread form. The American practice gave more lattitude in production, resulting in a production margin that exceeded the agreed tolerance quite considerably. Conclusions drawn from the investigation included recommendations for the unification of standard screw plug gauges and taps to avoid production anomalies.

METAL FORMING

A detailed account of experiments on deep drawing carried out over a period of four or five years at the Technische Hogeschool, Delft, was given by Professor P. Landberg. The investigations included studies of wrinkling, blankholders and blankholder pressures, lubrication, changes in wall thickness, radial stretching in the shell, and reductions in the circumference of grid circles.

It is well known that different methods of plastically deforming metals can cause different residual stress patterns in the components produced by these methods. In a brief Technical Note, Sachs and Weiss (United States) described how such stresses have been critically analysed in order to differentiate between two different methods of manufacturing venetian blind strips.

MACHINE TOOLS

A most valuable and comprehensive account of the principles, techniques and apparatus employed in researches into machine tool design and performance at the Institute of Research on Machine Tools and Metal Cutting, Prague, was given by Dr. Jiri Tlusty, Head of Machine Tool Research. The paper confirmed that great progress has been made by Dr. Tlusty and his colleagues in researches into machine tool vibration, and some novel instruments which were described excited keen interest. Although substantial progress has also recently been made in this country in extending the boundaries of knowledge in this field, it is not generally realised that present limits of speed, feed, tool life, surface finish, and accuracy in everyday production practice are often set by the vibration characteristics of machines and cutting tools. Full understanding of the nature and effects of these vibrations will help to remove present barriers to making substantial increases in the efficiency of existing techniques, and lead to more efficient utilisation of carbide and ceramic cutting tools.

PERA, for example, has made great progress in solving a variety of vibration problems, but reports of research being carried out not only in Czechoslovakia but in Russia, Germany, United States, etc., indicate that Britain is lagging behind these countries in the scale of vibration research. Despite the advances made by Dr. Tlusty and his colleagues, however, the Czechoslovakian investigators are obviously acutely aware that much still remains to be done in this field, and Dr. Tlusty invited the co-operation of research workers everywhere in improving machine tool research techniques and equipment.

DIFFUSED GRAPHITE CAST IRON

J. Pomey (France) gave a detailed account of the structure, heat treatment, mechanical properties, and machinability of diffused graphite cast iron. He claimed that this material will fill a gap existing between conventional malleable iron and die-forged steels in the production of small machine parts where high productivity and low costs are being sought.

SWISS ENGINEERING ANNIVERSARY

The Swiss Society of Machine Manufacturers recently celebrated their 75th anniversary. The expansion of this industry since the war has been most impressive. Between 1945 and 1957 the labour force it employs has risen to 170,000, an increase of 55 per cent. The value of exports rose in the same period from 568 million to 2,021 million Swiss francs. The industry has achieved a rapid expansion of productivity which has kept prices down in spite of increases of 28 per cent in wages and 40 per cent in raw material costs since 1947.

One of the most successful sectors of the Swiss engineering industry has been the manufacture of electrical generating plant. This ranges from hydraulic and gas-turbine plants and electric generators to a variety of appliances and safety devices for electrical installations. The oldest branch of the machine making industry is the manufacture of textile machinery. This is closely followed by machine tools which have made very considerable progress over the past 30 years especially for high-precision instruments. Steam engines, locomotives and railway rolling stock are all exported. Switzerland is one of the leading makers of electric locomotives.

Over all this range of products the object has always been to concentrate on quality and the Swiss engineers are backed by active research organisations at factory level. For the future the Swiss expect to gain from two sources. First they expect to play a big part in manufacturing reactors, control apparatus, measuring instruments and so on for the European atomic energy industry. Secondly they believe that the economic expansion of the underdeveloped countries of the world will bring the Swiss machinery firms an entirely new set of customers.

Metals and Materials

COLOUR AND TEXTURE FOR ALUMINIUM EXTERIORS

The exhibition of colour-anodised aluminium for exterior use, which was held at the Building Centre, Store Street, London, W.C.1, from 1 to 10 October, demonstrated the wide scope in architectural design made possible by the new non-fade weather-resistant finishes.

Aluminium and certain selected alloys in the form of sheet, plate, sections and castings, have been used increasingly in building construction in the last decade for both structural and decorative purposes; windows, canopies, grilles, spandrels and doors in these durable materials are now a familiar sight in the large cities and industrial centres of many countries. The range of colours—bronze, gold, yellow, green, blue, with variations in shade or tone—in addition to the bright, matt, satin, embossed, patterned and other natural finishes of aluminium will considerably enhance the appeal of these building components.

Colour anodising has been used as a decorative finish for small aluminium articles, mainly for interior domestic use, for many years. The new finishes recommended for exterior use are the result of careful research and development work mainly carried out by the aluminium industry, including lengthy weathering tests under various atmospheric conditions. In this way it has been possible to select the most suitable dyed and pigmented anodised finishes as regards colour-fastness over a period of at least 5 years.

At the opening of the exhibition, Mr. J. H. Mayes, chairman of the building and structural engineering committee of the Aluminium Development Association, referred to the technical achievements which enabled anodising and colouring techniques to be applied to the larger components that aluminium fabricating plants were now able to supply. He described how the Association had collaborated with manufacturers and the anodising industry to ensure that everything possible was done to meet the requirements of architects as regards design, transport and erection problems, and satisfactory performance in service. Three members of the Association's technical staff then spoke on various aspects of the subject of the exhibition.

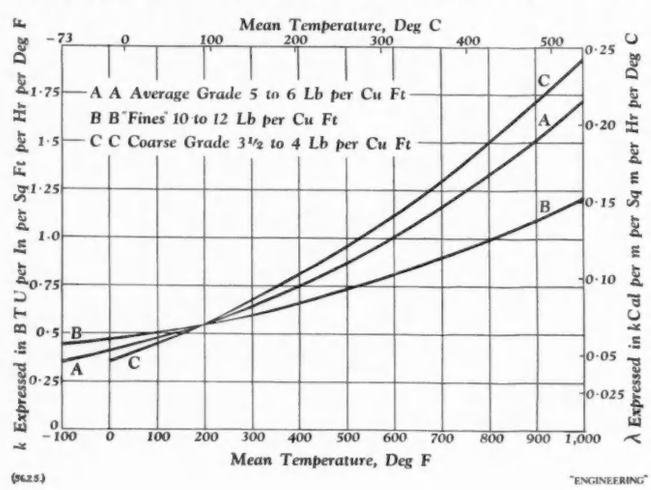
An account of the fabrication and anodising facilities was given by Mr. J. C. Bailey, who referred to the selection of alloys and quality of material required to provide the range of colours. Anodising baths 21 ft in length, 3 to 4 ft wide and 8 ft deep, were available for treating large building components. The effect of texture and alloy composition (particularly the 5 per cent silicon-aluminium alloy) on appearance and colour tone was mentioned. Mr. F. C. Porter emphasised the specification requirements for colour anodising, to ensure colour-fastness and durability of building components. These included a minimum (preferred) film thickness of 0·001 in, the use of the correct anodising technique and tested pigments and dyestuffs. He also mentioned methods of providing temporary protection for the surfaces during transport and erection. With the aid of slides Mr. H. W. Johnson described typical installations in France, Italy, Germany, Switzerland, USA and United Kingdom, where colour-anodised aluminium had been used to achieve striking architectural effects. The first example of exterior colour anodising in this country was in 1956 when 7,000 sq. ft of yellow-ochre anodised sheet was incorporated in the curtain walling of the Armstrong Siddeley Motors Research Centre, at Ansty, near Coventry. This building was designed and erected by Templewood Hawksley Limited, the sheet panels being N4 aluminium alloy anodised to a thickness of 0·001 in by Acorn Anodising Company Limited.

THERMAL CONDUCTIVITY OF VERMICULITE

A summary of the latest available data on the thermal conductivity of exfoliated vermiculite in three representative grades is given in the attached graph. These curves, which will become a useful reference for all concerned with loose-fill insulation and allied design problems, were produced from test data supplied by the National Physical Laboratory and by the Forschungsheim für Wärmeschutz, Munich, one of West Germany's leading research centres.

The point of intersection of the three curves, at approximately 200° F, is higher than was previously assumed. It is a feature of exfoliated vermiculite that while the larger, lighter grades are superior below that temperature, the smaller, denser material gives strikingly better results above 200° F.

The principal applications of exfoliated vermiculite are in domestic, furnace and cold store insulation and in packaging.



Thermal conductivity values for exfoliated vermiculite.

STAINLESS STEEL CONTAINS BERYLLIUM

Prior to 1953 attempts to harden 18/8 stainless steel with beryllium had proved disappointing, but in that year Cooper Alloy Foundry Company of New Jersey, USA, were awarded patent 2,635,044 covering a nickel-chromium alloy hardened with 0·15 per cent beryllium which has very useful properties. V2B stainless alloy, as it is called, has high corrosion resistance and hardenability, and is readily machined in the as-quenched condition. Unlike most 18/8 steels, it has little tendency to seize or gall when hot surfaces in the alloy come into intimate contact with one another, and it appears to be well suited for use in valve-discs, pump-impellers, gears and other parts subjected to wear. It should also prove useful in accessories which handle superheated steam and hot liquids, because it does not over-age in temperatures up to 1,400° F.

Chemical Compositon of V2B
Percentages

Carbon	..	<0·07	Manganese	..	0·50–0·75
Chromium	..	19·0–19·50	Copper ..	..	2·00–2·25
Nickel ..	..	9·75–10·25	Molybdenum	..	3·00–3·50
Silicon	..	2·75–3·25	Beryllium	..	0·10–0·20

Although primarily developed as a hardenable casting alloy, the properties of the wrought product are attractive: for instance, in the water-quenched and fully hardened condition a tensile strength of 150,000 lb per sq. in may be attained with a minimum elongation of 2 per cent.

Composition limits for V2B are tabulated above. Performance of the alloy is comparable with 316 stainless, which achieves good machinability and strength from the hardening induced by precipitation of a sulphide phase. The great advantage over 316 stainless is that the corrosion resistance in all but concentrated boiling nitric acid is better, an indication that the disperse phase of beryllide which causes hardening in V2B is not so harmful as the sulphide phase in 316.

Further data sheets for the alloy are available from Beryllium Smelting Company Limited, 36/38 Southampton Street, London, W.C.2, who, as agents for the Cooper Alloy Corporation, are offering a licensing agreement to any British firm interested in production of this stainless steel.

POSTGRADUATE EDUCATION IN AIRCRAFT MATERIALS

"Aircraft Materials" are the subject around which a new major department has just been established at the College of Aeronautics, Cranfield. Professor Kennedy, B.Sc., Ph.D., A.M.I.E.E., F.Inst.P., who was last year appointed head of the major department-in-embryo, is now able to steer his postgraduate students through a course in which the second year may consist of specialisation in the engineering applications and theoretical sciences of aircraft materials. Students who so specialise will co-operate in the several research investigations in creep and fatigue which are now in progress as essential activities of the department.

It is fully realised that there is much in the syllabus which is of general interest, and it is therefore intended to form a short course of about two months duration, which would be open to anyone in industry concerned with engineering materials who would be interested in modern developments in materials theory and technology.

Those interested in such an advanced course are invited to write to him so that he may assess the demand, and may mould the future course into its most useful form.

NOTICES OF MEETINGS

British Institution of Radio Engineers

NEWCASTLE UPON TYNE
"Use of Transistors in Communication and Control Equipment," by E. Wolfendale. North Eastern Section. Neville Hall, Westgate Road, Newcastle upon Tyne. Wed., 12 Nov., 6 p.m.
TREFOREST
"Problems of Television Servicing," by E. A. W. Spreadbury. South Wales Section. College of Advanced Technology, Treforest. Wed., 12 Nov., 6.30 p.m.
WOLVERHAMPTON
"Transistors in Television Receivers," by B. R. Overton. West Midlands Section. Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton. Wed., 12 Nov., 7.15 p.m.

Building Centre

LONDON
Technical film: "The Ceramic Tile," exhibited by H. and R. Johnson Ltd. Wed., 12 Nov., 12.45 p.m.

Chemical Engineering Group

LONDON
"Integrated Iron and Steel Works," by W. B. Wright and W. Elland. Society of Chemical Industry, 14 Belgrave Square, S.W.1. Tues., 11 Nov., 6 p.m.

Chemical Society

LONDON
Centenary Lecture: "Inorganic, Organic and Technological Aspects of ^{15}N-Chemistry," by Professor Dr. K. Clusius. Royal Institution, Albemarle Street, W.1. Thurs., 13 Nov., 7.30 p.m.
DURHAM
"Bond Dissociation Energies in Polyatomic Molecules," by Dr. H. A. Skinner. Durham Branch. Science Laboratories, The University, Durham. Mon., 10 Nov., 5 p.m.
EDINBURGH
"Packaging," by Dr. G. L. Riddell. Edinburgh Branch. North Bristol Hotel, Edinburgh. Thurs., 13 Nov., 7.30 p.m.
HULL
"Explosives," by Dr. B. D. Shaw. Hull Branch. Organic Chemistry Lecture Theatre, The University, Hull. Tues., 11 Nov., 5 p.m.

Electrical Association for Women

LONDON
"A Month in America," by Marjorie Pickford. 14th Caroline Haslett Trust Lecture. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Wed., 12 Nov., 2 p.m.

Faraday Society

NEWCASTLE UPON TYNE
"Tracer Diffusion and Self-Diffusion in Concentrated Electrolytes," by Professor R. H. Stokes (University of New England, N.S.W., Australia). Chemistry Department, King's College, Newcastle upon Tyne. Fri., 14 Nov., 5.30 p.m.

Illuminating Engineering Society

LONDON
"Practical Considerations in the Design and Manufacture of Neon Signs," by A. Urquhart. Federation of British Industries, 21 Tothill Street, S.W.1. Tues., 11 Nov., 6 p.m.

Incorporated Plant Engineers

BRISTOL
"Education in Industry," by E. G. Sterland. Western Branch. Grand Hotel, Broad Street, Bristol. Wed., 12 Nov., 7.15 p.m.
COVENTRY
"Maintenance of Automatic Plant," by J. Ward. Birmingham Branch. Hotel Leofric, Coventry. Fri., 14 Nov., 7.30 p.m.
DUNDEE
"Industrial Refrigeration," by R. Campbell. Dundee Branch. Taypark Hotel, West Ferry, Dundee. Wed., 12 Nov., 7.30 p.m.
GLASGOW
"Packaged Oil-Fired Boilers," by Alan Wilson. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall Street, Glasgow. Thurs., 13 Nov., 7.15 p.m.
MANCHESTER
"Radioisotopes in Industry," by W. G. Busbridge. Manchester Branch. Engineers' Club, Albert Square, Manchester. Tues., 11 Nov., 7.15 p.m.
NEWCASTLE UPON TYNE
"The Gas Turbine," by H. R. Beaton. North East Branch. Roadway House, Oxford Street, Newcastle upon Tyne. Thurs., 13 Nov., 7 p.m

Institute of Marine Engineers

LONDON
"Modern Marine Steam Turbines," by J. H. Gooch. Junior Lecture. Willesden Technical College, N.W.10. Mon., 10 Nov., 6 p.m.
"Design and Building of Ice Breakers," by A. Watson. Tues., 11 Nov., 5.30 p.m.*
BRISTOL
"Modern Marine Water-Tube Boilers," by Lieut.-Commander A. P. Monk, R.N. (ret.). West of England Section. Grand Hotel, Bristol. Mon., 10 Nov., 7.30 p.m.
GLASGOW
"Some Notes on Recent Reduction Gears for Propulsion Purposes," by S. Archer. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 12 Nov., 7.30 p.m.

Institute of Marine Engineers and Institution of Naval Architects

PORTSMOUTH
"A Review of Marine Steam Turbine Feed Cycles," by Commander A. D. Bonny, R.N. (ret.). Southern Joint Branch. Portsmouth College of Technology, Portsmouth. Fri., 7 Nov., 7.30 p.m.

Institute of Metals

BIRMINGHAM
"Steels for Extrusion Tools," by F. Rodgers. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., 13 Nov., 6.30 p.m.
GLASGOW
"Practical Application of Cathodic Protection in the Marine Field," by J. K. H. Tait and R. J. Thubron. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Mon., 10 Nov., 6.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Research on the Testing and Performance of Commercial Vehicle Brakes," by Dr. H. J. H. Starks. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Tues., 11 Nov., 7.30 p.m.
BRISTOL
Discussion on "Rolls-Royce Diesel Power." Western Centre. Royal Hotel, Bristol. Wed., 12 Nov., 7 p.m.
MANCHESTER
"Chassis and Engine Manufacture," by R. P. Chilton. East Regional Centre. Houldsworth Hall, 90 Deansgate, Manchester. Mon., 10 Nov., 7.45 p.m.

Institution of British Agricultural Engineers

LONDON
"Design of a Power-Frame Tractor," by H. E. Ashfield. Mon., 10 Nov., 2.15 p.m.

Institution of Chemical Engineers

MANCHESTER
"Design and Operation of Refrigeration Plant in the Chemical Industry," by D. M. Elliott and R. Parkins. North Western Branch. Chemical Engineering Building, Manchester College of Science and Technology, Jackson Street, Manchester. Tues., 11 Nov., 6.30 p.m.

Institution of Civil Engineers

LONDON
"Merdeka Bridge, Singapore: the Investigation, Design and Construction," by R. J. Hollis-Bee. Tues., 11 Nov., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "How Safe Are Domestic Electrical Appliances?" opened by H. G. F. Gamble. Mon., 10 Nov., 5.30 p.m.*
BELFAST
"Digging up the Past" (Early Electrical Engineering Devices), by C. Snowdon. Northern Ireland Centre. Civil Engineering Department, Queen's University, Belfast. Tues., 11 Nov., 6.30 p.m.
CARDIFF
"Supply Voltage and Current Variations Produced by a 60 ton 3 Phase Electric-Arc Furnace," by Dr. B. C. Robinson and A. I. Winder. Western Centre. South Wales Institute of Engineers, Park Place, Cardiff. Mon., 10 Nov., 6 p.m.*
GLASGOW
"Recognition of Moving Vehicles by Electronic Means," by T. S. Pick and A. Readman. South West Scotland Sub-centre. 39 Elmbank Crescent, Glasgow, C.2. Tues., 11 Nov., 7 p.m.
NEWCASTLE UPON TYNE
"Investigations of Power-Follow Current Phenomena Using a Synthetic Power Source," by Dr. L. L. Alston and Professor F. M. Bruce; and "Impulse Initiation of Arc Discharges," by Dr. L. L. Alston. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 10 Nov., 6.15 p.m.

Institution of Electrical Engineers and British Nuclear Engineering Conference

LONDON
"Electrification of the UKAEA Industrial Group Factories," by J. W. Binns and W. J. Outram. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Thurs., 13 Nov., 5.30 p.m.*

Institution of Electronics

PORTSMOUTH
"Applications of Computers," by R. S. Evans. Southern Division. College of Technology annexe, Anglesea Road, Portsmouth. Fri., 14 Nov., 7 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
Debate on "There is no Future in Low-Pressure Hot-Water Heating," opened by J. C. Byles. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham. Tues., 11 Nov., 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"Developments in the Detail Design of Diesel Locomotives," by B. W. Anwell. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Wed., 12 Nov., 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
"Fatigue Testing of Vehicle Components," by T. C. F. Stott. Automobile Division. Tues., 11 Nov., 6 p.m.*
Discussion on "Flow—The Origin and Nature of Turbulence: Boundary-Layer Occurrences." Hydraulic Group. Thurs., 13 Nov., 6 p.m.*
"Experimental Investigation into the Effects of Cross Flow with Condensation of Steam and Steam-Gas Mixtures on a Vertical Tube," by T. Furman and H. Hampson. Meeting in conjunction with the Steam Group. Fri., 14 Nov., 6 p.m.*
EDINBURGH
"The Steam Catapult," by Commander C. C. Mitchell. Scottish Branch. North British Hotel, Edinburgh. Fri., 14 Nov., 6.30 p.m.
MANCHESTER
"Test Bed Installations and Engine Test Equipment," by the late H. G. Freeston. North Western Branch. Engineers' Club, Manchester. Thurs., 13 Nov., 6.45 p.m.
SHEFFIELD
"World's Largest Walking Dragline," by C. McL. Cameron. The University, St. George's Square, Sheffield. Wed., 12 Nov., 6.30 p.m.

Institution of Production Engineers

BLACKBURN
"Work Study as an Aid to Management," by W. H. Vale. Preston Section. Municipal Technical College, Blakey Moor, Blackburn. Wed., 12 Nov., 7.30 p.m.
IPSWICH
"Joining Dissimilar Metals," by A. A. Smith and J. G. Young. Ipswich and Colchester Section. Golden Lion Hotel, Cornhill, Ipswich. Fri., 14 Nov., 7.30 p.m.
LEEDS
"Automation Tendencies in the USA," by Dr. D. B. Foster. Hotel Metropole, Leeds. Mon., 10 Nov., 7 p.m.

Institution of Public Health Engineers

LONDON
"Water Conservancy: A World Problem," by Sir Eric Rideal. At Public Works Congress, Olympia, W.14. Mon., 10 Nov., 3 p.m.

Institution of the Rubber Industry

LONDON
"Rubber Products for the Motor Industry," by C. H. Gregory; and "Natural Rubber Compounds for High Temperature Service," by S. G. Fogg. London Section. 26 Portland Place, W.1. Tues., 11 Nov., 5.30 p.m.

Institution of the Rubber Industry and Plastics Institute

LIVERPOOL
"Activities of the NCB Scientific Department: Underground Trials on Conveyor Belts," by J. G. Norvall; "Laboratory Tests on Conveyor Belts and Their Correlation with Trials Results," by D. Bulgin. Adelphi Hotel, Liverpool. Fri. 14 Nov., 7.30 p.m.

Institution of Structural Engineers

LONDON
"Technical Education and Professional Training," by D. A. G Reid. Thurs., 13 Nov., 6 p.m.*

Junior Institution of Engineers

LONDON
Chairman's Address "Development of the Iron and Stee Industry," by P. Cameron. Fri., 14 Nov., 7 p.m.*

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Notes on the Longitudinal Strength of Tankers," by J. M. Murray. Literary and Philosophical Society's hall, Newcastle upon Tyne. Fri., 14 Nov., 6.15 p.m.*

Royal Institution

LONDON
"Colour Television: Progress During the Last Decade," by G. G. Gouriet. Fri., 14 Nov., 9 p.m.

Royal Society

LONDON
Discussion on "Space Research." Institution of Civil Engineers, Great George Street, S.W.1. Wed., 12 Nov., 2.30 p.m., and Thurs., 13 Nov., 10 a.m. (Tickets required.)

Royal Society of Arts

LONDON
"Modernising the Railways: Motive Power and Operation," by Cecil J. Allen. Wed., 12 Nov., 2.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Brick Quality and Furnace Construction Methods," by G. A. Smith. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 11 Nov., 7 p.m.

Society of Chemical Industry

LONDON
"Plastics and Other Polymers as Sources of Corrosive Vapours," by H. G. Cole and Mrs. V. E. Rance; and "Plastics for Protection Against Corrision," by A. C. Docherty and H. Hughes. Corrosion and Plastics & Polymer Groups. Wed., 12 Nov., 6.30 p.m.*

West of Scotland Iron and Steel Institute

GLASGOW
"Slag Composition," by K. Sharp. Fri., 14 Nov., 6.45 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
British Nuclear Energy Conference, Great George Street, London, S.W.1. (WHItehall 4577.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Electrical Association for Women, 25 Foubert's Place, London, W.1. (GERrard 5212.)
Faraday Society, 6 Gray's Inn Square, London, W.C.1. (CHAncery 8101.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, London, S.W.1. (SLOane 0469.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave Square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria Street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row London, S.W.1. (VICtoria 0786.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Plastics Institute, 6 Mandeville Place, London, W.1. (WELbeck 5439.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Society of Chemical Industry, 14 Belgrave Square, London, S.W.1. (BELgrave 3681.)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)

Research and Development

FATIGUE STRENGTH OF AN EMBEDDED POINT CARRYING A SHEAR LOAD*

By

D. A. Harding,

B.A., B.SC., A.C.G.I.

and

N. B. Owen,

A.M.I.MECH.E.

During early trials of the N.P.L. portable marine torsionmeter a fatigue failure occurred of one of the case-hardened mild-steel gauge points by means of which the instrument was attached to a ship's propeller shaft. The tests described herein were made to obtain information on the range of shear loading which could safely be carried by such a joint, with the object of improving the design. The results showed that a gauge point held in an indentation had outstanding fatigue strength, a feature which might have wider applications, and with this object in view the results are reported below.

The joint consisted of a 90° conical steel point located in a similar conical indentation under a constant load maintained by springs. The alternating load was applied transversely to the common axis of the point and indentation. The set-up in the N.P.L. 1500 lb slipping-clutch fatigue-testing machine, which was described on page 84 of ENGINEERING for 18 July, 1958, is shown in Fig. 1.

The pointed member was of 3 per cent nickel-chromium-molybdenum steel (En27) hardened and tempered to Vickers Diamond Pyramid Number (VPN) 380-420 hardness; the point was slightly truncated to ensure contact with the indentation over the conical surface without contact at the bottom of the indentation. A single test was also made with a 25 tons per sq. in mild-steel point of hardness VPN 112; this point was formed on a shank $\frac{1}{4}$ in diameter held in the test rig by a collet. Another test was made with a point formed on a piece of $\frac{7}{32}$ in diameter Deloro Stellite tool metal.

The indentation was made in the face of a mild steel nut (VPN 170) by punching with a sharp pointed hard conical punch having the same 90° angle as the hard steel point. The diameter of the indentation at the surface of the nut was measured by means of a microscope.

DETAILS AND RESULTS OF TESTS

In each test the point was pressed into the indentation under a load of 400 lb, maintained virtually constant by the springs seen on the right at the centre of Fig. 1. Each point was subjected to a load range of about ± 325 lb, the loading condition being varied by varying the initial diameter of the indentation from 0·05 in to 0·13 in. The results of the tests are listed in the Table, where the nominal range of shear loading is quoted as the ratio of the load range

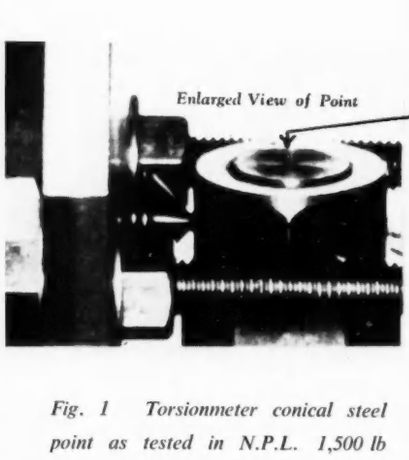


Fig. 1 Torsionmeter conical steel point as tested in N.P.L. 1,500 lb slipping-clutch fatigue testing machine.

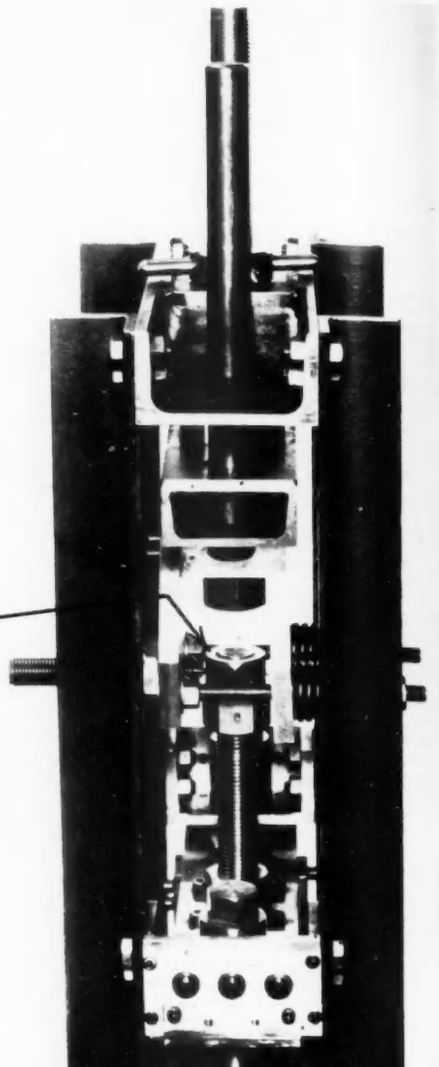
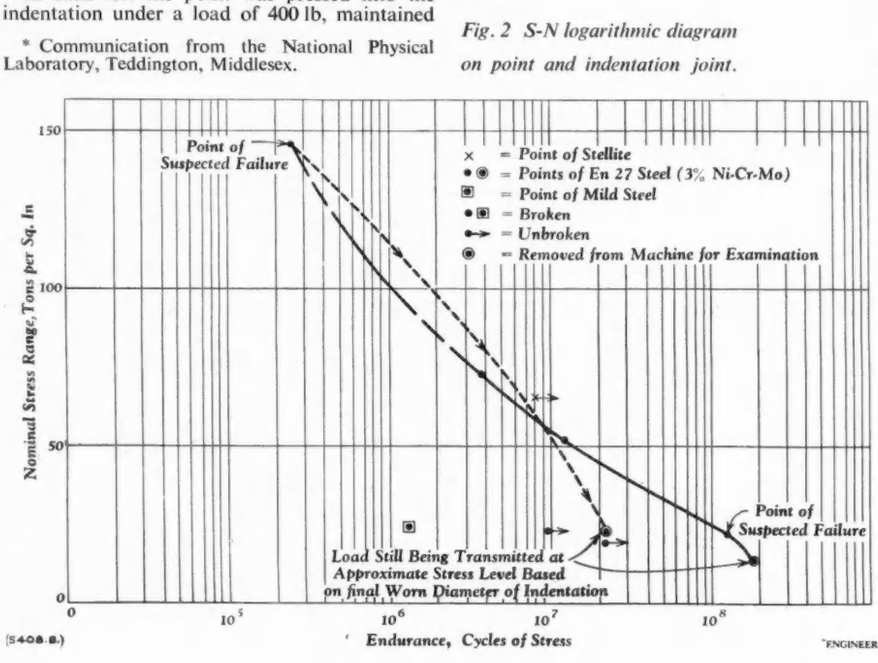


Fig. 2 S-N logarithmic diagram on point and indentation joint.



TABLE—*Results of Fatigue Tests on Point and Indentation Joint*

Point material	Indentation dia.	Nominal stress range	Endurance
	In.	tons per sq. in.	× 10⁶ cycles
3 per cent Ni-Cr-Mo steel (En 27)	0·050	147	0·26*
			21·61†
	0·071	73	3·87B
	0·084	52	12·64B
	0·124	24	9·44U
	0·126	23	137·00*
			195·00†
	0·136	20	21·64U
Mild steel	0·124	24	1·26B‡
Stellite	0·074	67	8·18U

B = Broken. U = Unbroken.
* Suspected failure of point.
† Joint removed from machine and failure confirmed.
‡ Failure occurred at $\frac{1}{4}$ in diameter shank and not at point.

* Communication from the National Physical Laboratory, Teddington, Middlesex.

(650 lb) to the initial area of the indentation at the surface of the nut. These results are shown also as an S-N diagram in Fig. 2.

The long endurances obtained under high stresses were in themselves surprising; but a still more surprising result was that two of the joints, the smallest and the largest, never really failed at all. After endurances more or less consistent with those of the other joints which failed, the machine cut out; but on examination *in situ* the joints appeared to be intact. Moreover, when the machine was restarted it ran quite normally and it continued to do so for endurances so long that the tests were eventually discontinued, while the joints were still carrying the load. On dismantling these joints the tips of the hard steel points were found to have broken off, and it seemed probable that this occurred when the machine first shut down. However, the fracture surface lay below the surface of the nut and the load was being transmitted through the narrow annulus left between these two surfaces and possibly also by the keying of the broken parts due to the compressive load.

The point formed on the Stellite tool metal was unbroken after 8 million cycles, and although this exceeded the estimated life of points of En 27 steel the test was discontinued because the indentation appeared to be more severely worn than with the En27 steel points.

Points of En 27 steel, hardened and tempered, were used in the final design of the torsionmeter because not only was their strength adequate but they were simple to manufacture.

FRETTING CORROSION AND FRACTURE

All the joints fretted very severely, indeed at times the iron oxide seemed almost to be " leaking " from the joint, and the corrosion product appeared to come chiefly from the mild steel. Perhaps due simply to the loss of material by fretting, or possibly due also in part to continuing plastic deformation of the mild steel, the hard steel points tended to advance into the mild-steel nut. For instance the diameter of the smallest joint tested which was initially 0·050 in, had by the time the test was discontinued increased to 0·125 in. The two components of this joint at the conclusion of the test are shown at the top of Fig. 3 and below, for comparison, is shown an unbroken point. The broken tip may be seen embedded in the nut, and the dark ring of fretting product on the broken point indicates the region of contact in the later stages of the test.

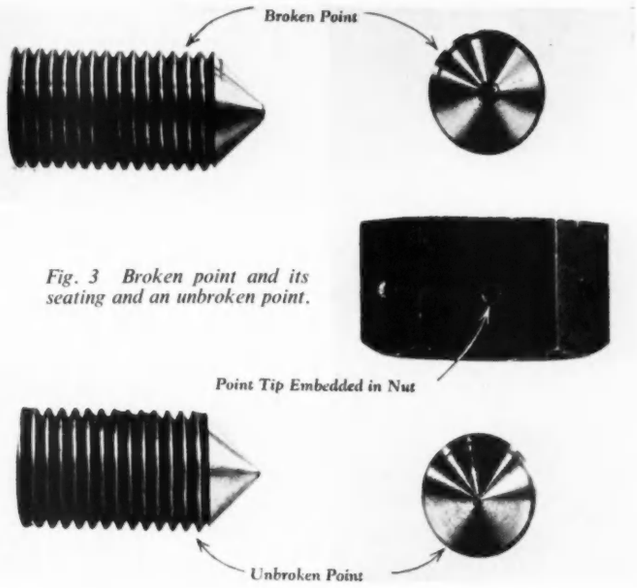


Fig. 3 Broken point and its seating and an unbroken point.

Fracture of the hard steel point always occurred below the surface of the nut, and the tip broken off remained firmly embedded in the nut. It seems that if the fracture occurs sufficiently far below the surface so that the annulus left is wide enough to prevent the joint from falling apart at once, the broken point is able to go on eating its way into the nut, pushing its detached tip ahead of itself and the joint may never actually fail.

The failure of the mild steel point is of interest since fracture occurred not at the point, which was badly worn away, but at the $\frac{1}{4}$ in diameter shank at a zone of fretting which had occurred between the shank and collet. The primary cause of the failure was the high bending stress, about $\pm$ 15·0 tons per sq. in, imposed by the applied alternating load, and the fretting simply accelerated the process.

Acknowledgments.—The work described has been carried out at the National Physical Laboratory as part of the research programme of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of the National Physical Laboratory and the Director of Mechanical Engineering Research.

NON-COMPETITORS POOL THEIR RESEARCH

Research is a very necessary item to-day, but also a very expensive one. Consequently, there has been a tendency for co-operative research to be undertaken by a group of interested parties. A particular example showing how non-competing groups can work together, is the Office for Research and Experiments of the International Union of Railways. After the 1914-18 war, a step in collaboration was taken in the formation of the International Union of Railways (UIC), with headquarters in Paris, directed towards restoring international railway traffic to pre-war standards. After the 1939-45 war a similar need arose; and more urgently. For not only were there six years of war damage and virtual technical stagnation to be made good, but also there was much keener competition than after 1918. Consequently ORE, with headquarters in Utrecht, was created by the Board of Management of UIC in 1949.

The pooling of research in this way enables each of the member bodies to gain from the experience of the others, and to spread the financial responsibility of the undertaking among them all. Questions put to the ORE are classified under different headings such as electrical, motive power and rolling stock, vehicle and track interaction, civil engineering and mechanics. Results achieved to date give promise of the benefits to be obtained by railways from willingness to combine efforts rather than to seek progress in isolation.

At present there are about 46 questions on the programme for consideration. A very pertinent one in view of the widespread electrification programmes in Europe concerns the behaviour of a pantograph and catenary at high speeds. Recently a report on tests carried out with alternating current pantographs was published, giving the results of runs in excess of 100 m.p.h. on the French National Railways. Another investigation concerns the standardisation of passenger and freight rolling stock—a report summarising the results of dynamic and static load tests carried out on 12 international main line coaches was submitted to the control committee recently. At the same time a report containing recommendations for the construction of air conditioning and heating systems in coaches was submitted. A more general study of heating and ventilating systems is being made and the construction of a climatisation chamber to form part of an existing research centre in Vienna built by the Austrian Government in conjunction with ORE is envisaged.

ORE STRUCTURE

The UIC board of management created ORE with the following objectives: the pooling of means and results of research and trials; the carrying out on joint account of certain investigations; the examination of the rationalisation of means of construction and of the possibilities of dividing the work between the industries of various countries.

ORE has at present 27 " members," including railway Administrations such as British Railways and the Lower Congo-Katanga Railway, and allied organisations, for example, the Wagon Lits Company. The Indian railways were admitted to membership in 1957. All contribute to the " fund " required by ORE. The board of management nominates from them a control committee which supervises ORE work, meeting three times a year and reporting annually to the board of management, recommending fresh problems for study, making budgetary proposals, or presenting reports on work completed.

Three points must be stressed when considering ORE's methods of resolving questions. First, although ORE conducts its own day-to-day affairs, it works closely with the UIC and its six commissions, of which the fifth or technical commission is most concerned with ORE. A second point concerns the recommendatory nature of documents submitted by ORE on its work. It is for the UIC board of management, guided by the commission concerned, to apply results obtained by ORE and to decide whether new international regulations or specifications should be drafted on the subjects in question.

Finally, ORE possesses no research laboratories nor any special test track. So it has always aimed at collective utilisation of the laboratories and test installations of its members, as well as a potential field of experiment covering over 100,000 miles of track. The costs incurred in its studies are covered by a budget and joint account, and the results become the common property of ORE member administrations.

The method of working varies according to circumstances but, generally, when the Control Committee has accepted a question for inclusion in the programme, it appoints one or two rapporteurs, who in collaboration with the ORE engineers concerned, investigate the question with a view to drafting a preliminary report, the contents of which is often drawn largely from replies to ORE questionnaires. In appropriate cases an international specialists' committee is then formed, a step which may be taken at the outset if the need for rapporteurs is obviated by the existence of sufficient information on a topic. The specialists' committee submits a working programme to the control committee which, after approving that programme, watches progress and considers any interim reports made. The specialists meet either at ORE head-

Continuing

Research and Development

quarters or in other countries if, for example, it is required to attend tests relevant to their particular question.

The conclusion of the work leads to a report, to be sent to all member administrations: then the board of management, advised by the appropriate commission, must, as already mentioned, decide how to apply the results obtained.

MEASURING HUMIDITY

There are various methods for the accurate determination of humidity in the air. Most, however, are delicate and time-consuming techniques and are thus not suitable for application in industry. The instrument generally used for the purpose is the wet and dry bulb thermometer in which use is made of the empirical relationship between temperature readings and the humidity. For accurate results special precautions are necessary and there is consequently an urgent need for a simpler instrument for field work. The South African National Mechanical Engineering Research Institute is therefore engaged in the development of suitable methods for humidity measurement and particulars were given recently in a communiqué.

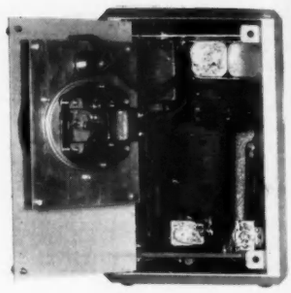
Various methods have already been developed and tried out. One of these is based on a principle similar to the wet and dry bulb instrument in which the rate of evaporation of water, and therefore its cooling effect on the wet bulb, depends on the amount of water vapour already in the air. The principal feature of the new instrument is a pair of concentric tubes with a vacuum between the two. The outer surface of the outer tube is silvered to prevent loss of heat. Air is drawn slowly through the inner tube, which is packed with a porous medium kept moist. The air passing through the tube becomes saturated with water vapour and reaches a temperature (the so-called adiabatic saturation temperature) dependent solely on the atmospheric temperature and the amount of moisture originally present in the air. The humidity can thus be calculated without the use of calibration curves or empirical tables.

Another instrument is being developed for the direct determination of the evaporation from the human body. This involves the measurement of minute changes in the humidity of a stream of air in which the body is placed. The instrument developed for this purpose depends on the fact that the electrical resistance of a crystal of pure salt changes sharply when the humidity of the air reaches a point at which the pressure of the water vapour it contains corresponds to the vapour pressure at the surface of the salt at a particular temperature. This equilibrium position is extremely critical and can be determined with the same degree of accuracy as temperature and resistance measurements.

An experimental model of this instrument was made and tried out by suspending in an air stream wetted models resembling to scale the evaporation from a human being. The values obtained compared well with the known evaporation determined by other means, and it is now proposed to carry out further tests with real subjects. This work finds practical application in research into the physiology of men who have to work under difficult environmental conditions such as are sometimes experienced in mines and factories.

Engineering at Home

IN TIME WITH CRYSTALS



In an article in this section last week, mention was made of the miniature quartz crystal clock produced by J. Langham Thompson Limited, Springland Laboratories, Bushey Heath, Hertfordshire. Illustrations of this clock have recently been made available to us, and we reproduce two of them on this page. The model shown is intended for industrial use, producing a pulse output suitable for driving a number of slave clocks. However, a domestic version has been developed for use in living rooms.

In the illustrations reproduced above, the encapsulated transistorised units can be seen on the left and the back of the cabinet interior; the stabilised power supply and secondary batteries are at the top. In the lower right-hand corner, the quartz crystal can be seen in its glass housing. A lamp is situated above the synchronous motor that turns the hands; it shines on a cadmium sulphide cell every half minute. The pulses from the cell are used as a basis for driving the slave clocks.

WOODEN POSTS STRONGER

The Australian Commonwealth Scientific and Industrial Research Organisation has found that some types of wooden fence posts are much stronger than the posts of concrete and steel normally available. Tests were carried out with posts of swamp gum and grey box, as compared with Y-section steel posts and 6 in by 4 in vibrated concrete posts. With loads applied in all cases at a height of 2 ft 6 in above ground level, it was found that the swamp gum failed at 5,300 lb, the grey box at 2,650 lb, the concrete post at 450 lb, the pre-stressed concrete post at 900 lb and the steel post at 200 or 240 lb (according to the direction of loading).

A farm survey by the CSIRO has also shown that concrete posts are not more durable than wood. Moist air and ground water penetrate them and cause rust to develop. This allows the concrete to come away from the reinforcement and weakens the post. Round wooden posts, treated with reliable preservative, last between 20 and 30 years, say the CSIRO, irrespective of the timber.

An unusual method for preserving hardwood poles, electrical transmission poles, and other timber structures contacting the ground, in use in Australia, employs oxy-welding for securing and charring the timber. The technique prevents decay due to fungi, termites and other wood-destroying agents.

The high-temperature flame produces a charred layer on the timber, with a hard, fine textured and compararively strong adherence. It is of the right porosity to allow absorption and retention of creosote preservative, which is applied with a pressure spray while the pole is still warm.

TAILORING RADIO TO EAR AND BRAIN

Stereophonic experiments have been carried out by the BBC and United States broadcasters, in which signals for left and right speakers are transmitted from different stations. While valuable information accrues from such tests, the system is uneconomical and incompatible. Recently, further details were released of the Percival system (ENGRG., 12 Sep. '58, p. 366) of compatible single-channel stereo radio, developed by EMI Electronics Limited, Hayes.

The transition from ordinary to stereo reproduction involves transmitting information as to direction. It can be shown that the quantity of additional information is small compared with that for the audio content; hence, if directional information could be transmitted as an independent signal, the extra power and bandwidth required would also be small. In early experiments, the directional information was given by a voltage depending on the ratio of the envelopes of the normal left and right signals. The voltage was used to control the relative gains of the amplifiers supplying the left and right speakers. The stereo results obtained were inadequate.

Further development of the system involved recognition of the fact that the ears are able to determine the direction of certain types of sounds more readily than the direction of others. Accordingly it was necessary to process the original left and right signals in such a way that the directional information was weighted in accordance with the ability of the ears to detect the directions of various sounds; an attempt was made to match the radio channel carrying directional information to the sensory channel constituted by ear and brain. A successful demonstration of this system was given.

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